# 40
# QUESTIONS ON BOTANY
## WITH
# ANSWERS



A MANUAL OF BOTANY FOR INDIAN STUDENTS).

By

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## PRINCIPLES & OUTLINE OF CLASSIFICATION (294—301).

36. What are the general principles of Classification? (C. U. 1917, 1920) 294—295. Give an outline of any modern system of classification (C U. 1910, 1913, 1920) 295—300. Write short notes on—Species, Variety, Race, Genus, Natural Order and the Name of a plant (C. U. 1911, 1913) 300—301.

## LIFE-HISTORIES (302—439).

37. Classify the Algae 302—303, Fungi 304 and Lichens 305. Describe the life-histories of—Gloeocapsa 305—306, Oscillatoria 306, Nostoc 307, Pleurococcus 308, Volvox 309—310, Oedogonium 311—314, Ulothrix 314—317, Desmids 317—318, Spirogyra* 319—320 (C. U. 1911, 1913), Diatoms 321—322, Vaucheria 322—325, Chara 325—330, Fucus 330—334, Polysiphonia 334—336, Bacteria 336—338, Myxomycetes 338—341, Mucor* 341—343 (C. U. 1909, 1910, 1918), Phytophthora & Pythium 344—346, Eurotium 347—348, Penicillium 348—350, Claviceps 350—352, Yeast* 353—354 (C. U. 1914, 1916, 1920), Puccinia 354—357, Agaricus 358—360, Lichens 360—365, Marchantia 365—372, Funaria* (Moss) 372—382 (C.U. 1912, 1914, 1917) Aspidium* (Fern) 384—392 (C. U. 1915, 1919, 1920, 1921, 1922), Heterosporous Ferns (Salvinia, Azolla, Pilularia, Marsilia) 393—399, Equisetum

399-405, Lycopodium 405—410, Selaginella* 410—419, Cycad (Zamia) 420—425, Pinus* 425—439. State clearly the phenomenon of "alternation of generations" in those life-histories in which there is a clear indication of it.

38. Indicate clearly the phenomenon of "Alternation of Generations" in Monocotyledons and Dicotyledons (439—440) and state the principal points of difference between the (A) Algae and Fungi 440—441 (C. U. 1913, 1922), (B) Mosses and Ferns 441—442, (C) Ferns, Monocotyledons and Dicotyledons 442—445 (C. U. 1912) and (D) Monocotyledons and Dicotyledons 445—446 C. U. 1919).

## GENERAL TERMS (447—460).

39. Write short notes on the following terms—Achlamydeous Actinomorphic, Adhesion, Albuminous seed, Aleurone grains (C U. 1910), Amplexicaul (C. U. 1921), Anatropous ovule (C U. 1916), Apogamy, Apospory, Aril (C. U. 1920), Bordered pits (C. U. 1917), Bract, Bracteole, Capitulum (C. U. 1920, 1921), Cladode (or Phylloclade) (C. U. 1916), Callus, Cambium, Capsule (C U. 1910), Carcerule, Caudex (or Stipe) C. U. 1916, Cohesion (C. U. 1910), Connective (C. U. 1910), Cordate, Corm (C. U. 1916), Corymb (C. U. 1913), Culm, Cuneate, Decussate (C. U. 1915), Deliquescent (C. U. 1917), Dermatogen, Diadelphous, Dichasium, Dichlamydeous, Dichotomous (C. U. 1915), Diclinous (or Unisexual), Didynamous (C. U. 1919), Dimorphism, Endosperm, Entomophilous (C. U. 1917), Epicalyx (C. U. 1919,

1920, 1921), **Epigynous** (C. U. 1916), Epipetalous, **Epiphyte** (C. U. 1919), Exalbuminous, **Excurrent** (C. U. 1917), Follicle, Funicle, **Gamete** (C. U. 1910, 1921), Gametophyte, **Geotropism** (C. U. 1910), **Graft** (C. U. 1917), **Guard-cells** (C. U. 1917), **Glume** (C. U. 1920), **Gynandrous** (C. U. 1921), Hastate, Haustoria, Hardbast, **Heliotropism** (C. U. 1917), **Hypanthodium** (C. U. 1921), **Hypogynous** (C. U. 1916, 1919), **Interpetiolar stipules** (C. U. 1919, 1920), Integument, Imbricate, Imparipinnate, **Involucre** (C. U. 1921), Isobilateral, **Labellum** (C. U. 1919, 1921), Lanceolate, Latex, **Legume** C. U. 1919), Lenticel, Leucoplast (or Leucoplastid), (Ligule, Lomentum, Lodicules, Lyrate, Meristem (or **Meristematic tissue**), **Monadelphous** (C. U. 1920), **Monochlamydeous** (C. U. 1915), Monoclinous (or Bisexual or Hermaphrodite), **Monoecious** (C. U. 1915), **Mucronate** (C. U. 1915), Nectary, **Nucellus** (C.U. 1921), **Nucleolus** (C.U. 1910), **Ochrea** (C U. 1921). Octants, Offset, Ovate, Palisade Parenchyma, Pollinia (C. U. 1921, **Papilionaceous** (C. U. 1920, 1921), Pappus, Parasite, Paripinnate, Parthenogenesis, Pedate, Pedicel, Peduncle, Peltate, Periblem, Pericarp, **Perigynous** (C.U. 1916), Perisperm, Phellogen (or Cork-cambium), Pinnatifid, Pinnatipartite, Pinnatisect, Plerome (C. U. 1910, Procambium, Prothallus (or Prothallium), Protandry, Protogyny, Protophloem, Protoxylem, **Pulvinus** (C. U. 1921), **Racemose** (C. U. 1915), Rachis, Reniform, Rhizoid. Rhizome, Runcinate, **Samara** (C. U. 1916), **Saprophyte** (C. U. 1917), Sagittate, **Scape** (C. U. 1916), **Scutellum** (C. U. 1910), Silicula, **Siliqua** (C. U. 1916), **Sinuous anther** (C U. 1920), **Sieve-tube** (C. U. 1917), **Sorosis** (C. U. 1916, 1921), **Sorus** (C. U. 1921), **Spadix** (C. U. 1919), Spathulate, Spathe, Spicate, **Spongy Parenchyma** (C. U. 1910), **Spore** (C. U. 1910), Sporophyll, Sporophyte, **Staminode** (C. U. 1920, 1921), Stele, Stipules, **Stolon** (or **Runner**) C. U. 1916, 1921 Stomata, Subulate, Sucker, Suspensor, Symbiosis, **Syngenesious** (C. U. 1919), **Tendril** (C. U. 1921), **Tetradynamous** (C. U. 1920). **Thallus** (C. U. 1921),

Tuber (C. U. 1919), Umbellate (C. U. 1915), Valvate, Vernation (C. U. 1915), Verticillaster (C. U. 1921), Zygomorphic (C. U. 1917).

## NATURAL ORDERS (458—528).

**40. Describe the following Natural Orders :—**

Gramineae, Cyperaceae, PALMACEAE, ARACEAE, LEMNACEAE, COMMELYNACEAE, Liliaceae, AMARYLLIDACEAE, IRIDACEAE, Scitaminaceae, Orchidaceae, PIPERACEAE, Urticaceae, POLYGONACEAE, Amarantaceae, NYCTAGINACEAE, PORTULACACEAE, CARYOPHYLLACEAE, NYMPHAEACEAE, RANUNCULACEAE, Menispermaceae, MAGNOLIACEAE, Anonaceae, Papaveraceae, CAPPARIDACEAE, Cruciferae, ROSACEAE, Leguminosae, Geraniaceae, OXALIDACEAE, Rutaceae, Euphorbiaceae, Anacardiaceae, Sapindaceae, VITACEAE, Rhamnaceae, Tiliaceae, Malvaceae, Sterculiaceae, Passifloraceae, Begoniaceae, CACTACEAE, Lythraceae Combretaceae, Myrtaceae, Umbelliferae, SAPOTACEAE, Apocynaceae, Asclepiadaceae, Convolvulaceae, Boraginaceae Verbenaceae, Labiatae, Solanaceae, Scrophulariaceae, Bignoniaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, CAMPANULACEAE, Compositae.

## APPENDIX (I—XXXVI).

Floral Diagrams of—Gramineae, Cyperaceae, Palmaceae, Araceae, Lemnaceae, Liliaceae, Amaryllidaceae, Scitaminaceae, Orchidaceae, Piperaceae, Urticaceae, Cruciferae, Papaveraceae, Leguminosae, Rutaceae, Euphorbiaceae, Anacardiaceae, Vitaceae or Ampelideae, Rhamnaceae, Tiliaceae, Malvaceae, Myrtaceae, Umbelliferae, Apocynaceae, Asclepiadaceae, Convolvulaceae, Boraginaceae, Verbenaceae, Labiatae, Solanaceae, Scrophulariaceae, Rubiaceae, Cucurbitaceae, Compositae.

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# Part IV.

# CLASSIFICATION OF PLANTS

OR

# SYSTEMATIC BOTANY.

# CLASSIFICATION OF PLANTS

OR

# SYSTEMATIC BOTANY.

**36. What are the general principles of classification ?** (C. U. 1917, 1920). **Give an outline of any modern system of classification.** (C. U. 1910, 1913, 1920). **Write notes on—Species, Variety, Race, Genus, Natural Order and the Name of a plant.** (U. C. 1911, 1913).

General Principles of Classification.

The object of *Classification* or *Systematic Botany* is to arrange into groups plants which resemble one another in fundamental characters and to separate plants which are less nearly allied ; these groups are then split up into many sub-divisions. In classifying plants, either of the two following systems are adopted :—In the first system of classification called the *artificial system,* plants are arranged according to one given principle which is more or less arbitrarily selected without considering whether or not the plants which bear close relationships with one another are always grouped together, and those which do not bear close relationships with one another are kept apart. In the second system of classification, called the *natural system,* plants are arranged according to their fundamental relation-

ships in the structure and other characteristics of the reproductive organs as well as in the peculiarities of the different forms which the majority of plants assume in the course of their lives. But a natural system which may seem to be perfect to-day, may be imperfect to-morrow owing to the discovery of many new plants. According to the present state of our knowledge of plants, we are in a position to establish certain great divisions of plants according to the natural system of classification which will not be seriously affected by subsequent discoveries.

## Outline of a modern system of classification.

Bentham and Hooker's system of classification has remained the standard one in Britain for a long time, but on the continent has long been superseded by the more natural system of Engler. We have therefore adopted this system of classification for the so-called *flowering plants*. The *Ferns and their allies* are classified according to the most recent views upon the subject. The vegetable kingdom is now divided into *four* sub-kingdoms or divisions which are (1) Thallophyta ; (2) Bryophyta ; (3) Pteridophyta or Vascular Cryptogams ; and (4) Spermaphyta. In view of recent researches on reproduction, the division of plants into *Phanerogams* and *Cryptogams*, the former being composed of the *Angiosperms* and the *Gymnosperms* and the latter of the *Thallophyta*, *Bryophyta* and *Pteridophyta*, is no longer in use. Some botanists still group together the *Gymnosperms* and the *Angiosperms* into the division known as the Spermaphyta

but there are others who consider the Gymnosperms and the Angiosperms as two primary divisions of the plant kingdom since, according to recent researches, there is a greater gulf between the Gymnosperms and the Angiosperms than between the Pteridophyta and the Gymnosperms. From a study of Palaeobotany we find that there is an intermediate division called the **Pteridosperms** (seed-bearing Ferns) which agree with the Gymnosperms in all essential characters.

## Thallophyta.

The vegetative body of the thallophyta consists of *thallus* which shows no differentiation into stem, leaf and root or such differentiation is very slight. The Thallophyta is divided into the following subdivisions :—(1) **Algae**, (2) **Fungi**, and (3) **Lichens**. The body of the *Algae* contains chromatophores. There is no chromatophore in the body of the *Fungi*. The fungi derive food materials from living or dead matters. Each Lichen is not a single plant but is made up of an Alga and a Fungus which live together for mutual advantage.

## Bryophyta.

The most important feature which distinguishes the plants of this division is that in their development there are always two well-defined stages, each stage terminating in the formation of reproductive cells. The more conspicuous stage in the life-history of these plants is called the *gametophyte* because it produces gametes (sexual cells). The other stage,

called the *sporophyte,* remains attached to the gametophyte and is more or less dependent upon it. The sporophyte bears the spores (asexual cells). These stages are generally called "generations" and in the Bryophyta there is a regular *alternation of these two generations,* the gametophyte being the more conspicuous. The Bryophyta is divided into two *classes*: (1) Haepaticeae or Liverworts, and (2) Musci or Mosses.

## Pteridophyta or Vascular Cryptogams.

In this division there is alternation of the two generations, sporophyte and gametophyte, the sporophyte being the more conspicuous. The sporophyte is quite independent of the gametophyte during the greater part of its life and the body of the sporophyte is differentiated into true stem, leaves and roots. Special tissues known as vascular tissues are developed in the sporophyte of the Pteridophyta, in consequence of which the plants under the Pteridophyta are also known as Vascular Cryptogams. The Pteridophyta is divided into the following *classes*:—(1) Filicineae (Ferns), (2) Equisetineae (Horsetails), and (3) Lycopodineae (Club Mosses).

## Spermaphyta.

The Spermaphyta is divided into (1) Gymnosperms and (2) Angiosperms.

Gymnosperms: In this group the ovules, before fertilisation, are not enclosed in an ovary formed by a carpel or carpels. The endosperm is formed *before* fertilisation. The Gymnosperms are divided into the following *classes*:—(1) Cycadales (stem with little branching; leaves pinnately divided, forming rosette at the end of stem; flowers dioecious, not grouped in inflorescence; no perianth); (2) Ginkgoales (stem branched with long and short shoots; leaves fan-shaped; flowers dioecious; stamen with 2 pollen-sacs;

ovules 1 or 2 at the end of rudimentary carpel) ; (3) **Coniferae** (stem branched ; leaves usually narrow, often linear ; flowers unisexual ; no perianth) ; (4) **Gnetales** (stem simple or branched ; leaves in pairs, undivided ; flowers unisexual or bisexual with perianth and more or less enclosed in bracts.

**Angiosperms** : In this group the ovules are enclosed in an ovary formed by a carpel or carpels. The endosperm is formed *after* fertilization. The Angiosperms are divided into the following *classes* :— (1) **Monocotyledons,** in which the embryo has one cotyledon, the flower is usually *trimerous* (that is, each whorl e. g. calyx, corolla etc. consists of *three* parts), the cambium is absent from the vascular bundles which are arranged in a scattered manner and the venation of foliage-leaves is generally parallel ; (2) **Dicotyledons,** in which the embryo has two cotyledons, the flower is usually *tetramerous* or *pentamerous* (that is, each whorl e. g. calyx, corolla etc. consists of *four* or *five* parts), the cambium is present in the vascular bundles which are arranged in a circle and the foliage-leaves usually have reticulated venation.

The **Monocotyledons** may be divided under the following heads according to the form and disposition of the parts of the flower :— 1) *Flowers with marked inequality in the number of parts ;* 2) *Flowers usually trimerous, rarely more or two-merous.*

The **Dicotyledons** may be divided into (1) *Archichlamydeae*, and (2) *Sympetalae.* In **Archichlamydeae,** the perianth, in lower stages of development, is either (*a*) absent, (*b*) in one whorl, petaloid or sepaloid, by the abortion of inner whorl, (*c*) in two whorls, the inner polyphyllous, or (*d*) in two whorls, the inner gamophyllous. In **Sympetalae,** the perianth, in higher stages of development, is always originally in two whorls, the inner gamophyllous (in a few cases polyphyllous or absent).

# Skeleton of the classification of Plant-Kingdom.

PLANT-KINGDOM.

- I. Thallophyta
  - *a.* Algae.
  - *b.* Fungi.
  - *c.* Lichens.
- II. Bryophyta
  - *a.* Haepaticeae. or Liverworts.
  - *b.* Musci. or Mosses.
- III. Pteridophyta
  - *a.* Filicineae.
  - *b.* Equisetineae.
  - *c.* Lycopodineae.
- IV. Spermaphyta
  - Gymnosperms.
    - *a.* Cycadales.
    - *b.* Ginkgoales.
    - *c.* Coniferae.
    - *d.* Gnetales.
  - Angiosperms.
    - *a.* Monocotyledons.
    - *b.* Dicotyledons.

**Inter. Questions on the "outline of a modern system of classification" from 1909-22.**

1. Give some idea of the main divisions into which the plant kingdom is divided. Define the divisions in a general way. (C. U. 1910).

2. Give an outline of any modern system of classification with which you are acquainted. (C. U. 1913).

3. Briefly describe any system of classification known to you. (C. U. 1920).

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## Species, Variety, Race, Genus, Natural Order and the Name of a plant. (C. U. 1911, 1913.)

**Species:** All individuals, which resemble one another so much as to make us believe that they are all, or may have been all, descended from a common parent, comprise a *species* e. g. *Solanum tuberosum* which includes all potato plants ( আলু, alu.)

**Variety & Race:** When a number of individuals of a species differ from one another, in the course of multiplication, in some striking characters, they form a *variety*. A variety differs from a species in the fact that it cannot be propagated and that it tends to revert to the original species. But there are some varieties, called the permanent varieties or *races* which can be propagated by seed provided they are under cultivation. But if the races are left to themselves on a poor soil, they tend to revert like ordinary varieties.

**Genus:** A collection of species, which resemble one another more than they do any other species, constitute a genus e. g. *Solanum*, which includes the species, *Solanum tuberosum* (আলু, alu, potato), *Solanum melongena* (বেগুন, begun, brinjal) and other similar species.

**Natural Order:** A collection of genera, which resemble one another specially with regard to flower, fruit and seed, constitute a *natural order*, e. g. *Solanaceae*. The name of a natural order is often derived from the most important genus.

**Name of a plant:** The name of a plant is derived from its *generic* name and *specific* name. The generic name indicates the genus to which the plant belongs and the specific name distinguishes the plant from others of the same genus. Thus the name of *Cucurbita Pepo* (শ্বেত কুমড়া, seth kumra) plant has the generic name, *Cucurbita*, and the specific name, *Pepo*.

**Inter. Questions from 1909-22.**

1. Illustrate, by Indian examples, the difference between species and genus. (C. U. 1911).

2. By referring to plants known to you, illustrate what is meant by the terms—Natural Order, Genus, Species, Variety. (C. U. 1913).

## 37. Classify the Algae, Fungi and Lichens. Describe the life-histories of—Gloeocapsa, Oscillatoria, Nostoc, Pleurococcus, Volvox, Oedogonium, Ulothrix, Desmids, Spirogyra* (C.U. 1911, 1913), Diatoms, Vaucheria, Chara,

**Fucus,** Polysiphonia, **Bacteria, Mucor*** (C. U. 1909, 1910, 1918), **Phytophthora,** Eurotium, Penicillium, **Yeast*** (C. U. 1914, 1916, 1920), **Claviceps, Puccinia, Agaricus, Lichens, Marchantia, Funaria*** (C. U. 1912, 1914, 1917), **Aspidium*** (C.U. 1915, 1919, 1920, 1921, 1922), **Heterosporous Ferns, Equisetum, Selaginella***, Lycopodium, Cycas and **Pinus.*** **State clearly the phenomenon of "alternation of generations" in those life-histories in which there is a clear indication of it.**

(Note : The students preparing for the Inter. Exam. of the Calcutta University should only read the life-histories marked with asterisk *).

# ALGAE.

## (Sub-division)

The body of the **Algae** contains *chromatophores*. The *Algae* are divided into the following classes :— (1) *Cyanophyceae*, (2) *Chlorophyceae*, (3) *Phaeophyceae*, and (4) *Rhodophyceae*. The **Cyanophyceae** are *blue-green* Algae containing a blue colouring-matter known as *phycocyanin*. Under Cyanophyceae, we shall study the following—*Gloeocapsa*, *Oscillatoria* and *Nostoc*. The **Chlorophyceae** are *green* Algae containing only *chlorophyll* and its derivatives. The Chlorophyceae are divided into the following **orders**—(*a*) **Protococcales,** under which we shall

study *Pleurococcus* and *Volvox*; (*b*) Confervales, under which we shall study *Oedogonium* and *Ulothrix*; (*c*) Conjugales, under which we shall study *Desmids* and *Spirogyra*; (*d*) Diatomales, under which we shall study the *Diatoms*; (*e*) Siphonales, under which we shall study *Vaucheria*; and (*f*) Charales, under which we shall study *Chara*. The Phaeophyceae are *brown* Algae containing a yellow or brown colouring-matter known as the *phycophoein*. Under Phaeophyceae, we shall study *Fucus*. The Rhodophyceae are *red* Algae containing a red or purple colouring-matter known as the *phycoerythrin*. Under Rhodophyceae, we shall study *Polysiphonia*.

## Skeleton of the classification of Algae.

**ALGAE (Sub-division).**

- Class: I. Cyanophyceae (Blue-green) — *Gloeocapsa, Oscillatoria, Nostoc.*
- Class: II. Chlorophyceae (Green)
  - Ord. 1. Protococcales — *Pleurococcus, Volvox.*
  - Ord. 2. Confervales — *Oedogonium, Ulothrix.*
  - Ord. 3. Conjugales — *Desmids, Spirogyra.*
  - Ord. 4. Diatomales — *Diatoms.*
  - Ord. 5. Siphonales — *Vaucheria.*
  - Ord. 6. Charales — *Chara.*
- Class: III. Phaeophyceae (Brown) — *Fucus.*
- Class: IV. Rhodophyceae (Red) — *Polysiphonia.*

# FUNGI.

(Sub-division)

The body of the Fungi contains *no chromatophore*. The fungi derive food materials from living or dead matters. The *fungi* are divided into the following classes :—(a) *Schizomycetes*, (b) *Myxomycetes*, (c) *Phycomycetes*, (d) *Ascomycetes*, (e) *Aecidiomycetes*, and (f) *Basidiomycetes*. Under Schizomycetes, we shall study *Bacteria*. The Phycomycetes are divided into two sub-classes—(1) *Zygomycetes* and (2) *Oomycetes*. Under *Zygomycetes*, we shall study *Mucor* and under *Oomycetes*, we shall study *Phytophthora*. Under Ascomycetes, we shall study *Eurotium*, *Penicillium*, *Claviceps* and *Yeast*. Under Aecidiomycetes, we shall study *Puccinia* and under Basidiomycetes, we shall study *Agaricus*.

## Skeleton of the classification of the Fungi.

FUNGI—(Sub-division)

Class :
I. Schizomycetes—*Bacteria*.
Class :
II. Myxomycetes.
Class :
III. Phycomycetes.
Sub-class : *Zygomycetes—Mucor*.
Sub-class : *Oomycetes—Phytophthora*.
Class :
IV. Ascomycetes—*Eurotium Penicillium* ; *Claviceps* ; *Yeast*.
Class :
V. Aecidiomycetes—*Puccinia*.
Class :
VI. Basidiomycetes—*Agaricus*.

# LICHENS.

(Sub-division)

Each Lichen is made up of an *Alga* and a *Fungus* which live together for mutual advantage. The *Lichens* can be divided into the following classes—(a) *Fruticose,* (b) *Foliaceous,* and (c) *Crustaceous.*

LICHENS.

| Fruticose. | Foliaceous. | Crustaceous. |
|---|---|---|

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# ALGAE.

( Sub-division )

Class I : Cyanophyceae (Blue-green).
Types : *Gloeocapsa, Oscillatori, Nostoc.*

## Type : GLOEOCAPSA.

## (Blue-green Algae).

Gloeocapsa (Flg. 124) occur at times in groups on damp rocks and walls. Each plant consists of a *single cell* which is either isolated or several of which lie together within the gelatinous wall of their mother-cell. Each cell consists of a *wall* and a mass of *protoplasm* ; *no nucleus* can be seen. The wall is peculiarly soft and forms concentric envelopes around the mass of protoplasm. Each plant multiplies by *division* in all directions, so that groups of daughter, grand-daughter and even great-grand-daughter plants may remain enclosed in the envelope of the original mother-cell which becomes very much swollen and jelly-

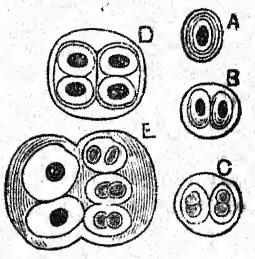


Fig. 124.

Fig. 124—*Gloeocapsa.* A—Single plant with the wall formed of concentric envelopes. B, C, D & E—Groups of plants within the wall of the mother-cell.

like. The outer walls of the groups of plants finally become changed to a soft mucilage.

—x—

## Type : **OSCILLATORIA** (Blue-green Alga).

(Fig. 125.A.)

**Habitat** : *Oscillatoria* is found in greatest abundance in open drains, ditches or pools where the water is foul with decaying organic matter. There it may form thick felts on the bottom or rise to the surface in slimy masses. **Microscopic structure :** Each plant consists of a chain of flattened cells which are usually covered with a delicate sheath. Each cell consists of a *wall* which encloses a *mass of protoplasm* in which the *blue-green colouring-matter is diffused*. There is *no nucleus* although the central region of the cell has a different structure from the outer and probably contains nuclear substance. The plant is not straight but is somewhat twisted into a very oblique spiral which turns on its axis. **Reproduction :** Reproduction takes place by the breaking of the plant into pieces, generally at some point where one or more cells have died (Fig. 125A.d). Each of these pieces moves about for a certain length of time, then comes to rest and grows into a new plant.

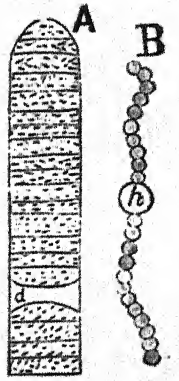


Fig. 125. *Oscillatoria* (A) & *Nostoc* (B)
*A—Oscillatoria* with a *dead* cell (d).
*B—Nostoc* with the *heterocyst* (h).

—o—

## Type: **NOSTOC** (Blue-green Algae).

(Fig. 125.B).

**Habitat**: *Nostoc vesicarium* may occur in water or lie loose on damp earth or among mosses in a lump of mucilage. **Microscopic structure**: Each plant consists of a chain of round cells. Single larger inert cells, termed *heterocysts* (Fig. 125B.h), are interposed at intervals in the chain. The heterocysts are incapable of further development and are generally devoid of protoplasm. They are lighter in colour and their function is not clearly understood. **Growth**: Each plant increases in length by the transverse division and growth of the individual cells. **Reproduction**: The plant normally multiplies by *division*. At the time of reproduction by division, the portions of the plant that lie between the heterocysts creep out of the mucilaginous substance, while the heterocysts themselves remain in it. Having come out of the mucilaginous substance, these portions of the plant, termed *hormogonia*, move about for a certain length of time and then come to rest. They then stretch themselves out and surround themselves with a mucilaginous envelope. Individual cells of the hormogonia, disposed apparently in no definite order, become heterocysts. In many forms, *resting spores* are formed by the enlargement of single cells, the walls of which become greatly thickened. *Resting nuclei* are present in these spores.

## Class. II. Chlorophyceae (Green).

Types : *Pleurococcus, Volvox, Oedogonium, Ulothrix, Desmids, Spirogyra, Diatoms, Vaucheria, Chara.*

**Order.** Protococcales.

## Type : **PLEUROCOCCUS** (Green Algae).

**(Fig. 126).**

**Habitat :** *Pleurococcus vulgaris* forms the green covering of wooden posts, damp walls and tree trunks after heavy rain. **Microscopic structure :** Each plant is a *single cell* which is composed of a *wall* enclosing a *mass of protoplasm*, a *large chloroplastid* and a *nucleus*. **Reproduction :** At the time of reproduction, each cell divides into two and thus two new cells (plants) are formed which subsequently become separated from each other. Frequently, instead of separating, the cells remain united with one another forming either a colony or a filament which ultimately breaks up into individual cells. **Other forms of reproduction: Asexual reproduction :** Sometimes the contents of a cell, on being set free, develop *two cilia*. The biciliate body, thus formed, swims about for sometime by the movement of cilia, then comes to rest, clothes itself with a wall and thus forms a new plant. **Sexual reproduction :** Sometimes similar *biciliate protoplasmic bodies* are formed which unite (conjugate) with each other. The body, thus formed e. g. zygospore, then clothes itself with a wall and develops into a new plant.

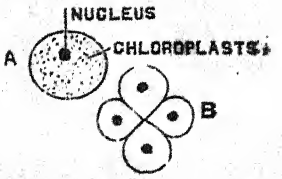


Fig. 126. *Pleurococcus*. *A*—The plant. *B*—Group of plants after division.

—o—

**Order.** Protococcales.

## Type : **VOLVOX** (Green Algae),

(Figs. 127 & 128).

**Habitat & Microscopic structure :** *Volvox globator* (Figs. 121. A & 128) consists of many hundreds of

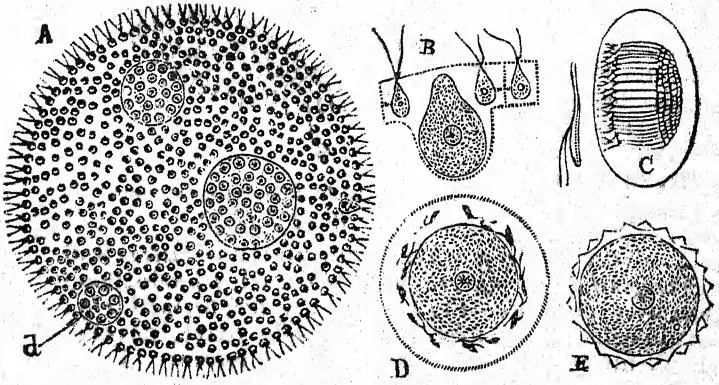


Fig. 127. *Volvox*.

A—Colony of *Volvox* with *three daughter colonies* (*d*) developing in its interior. B—Section of the edge of the colony showing *three smaller vegetative cells* and a *large developing female cell* (*oosphere*). C—A cluster of male cells (*spermatozoids*) within the parent cell (antheridial cell) and a *single spermatozoid* very much magnified at the side. D—A female cell (*oosphere*) surrounded by a swarm of male cells (*spermatozoids*). E—An *oospore* surrounded by a thick wall.

cells (sometimes more than twenty thousand) that are embedded in a gelatinous substance in the form of a sphere with the *pairs of cilia* pointing outwards. These groups (*colonies*) of cells, as large as pin heads, roll slowly through the water of quiet *pools and ponds*. Each cell consists of a mass of *protoplasm* containing a *nucleus* and a *chloroplastid* but *no cell-wall*. **Asexual reproduction:** Daughter colonies (Fig. 127 A. d) are formed from certain cells which, after a period of growth, develop a large number of motile cells like the parent. These small cells become arranged to form a daughter colony which swims around in the interior of the mother colony. Sometimes several of the daughter colonies are developed and they finally escape by the rupture of the parent structure. **Sexual reproduction:** The sexual organs are produced within the mother colony by the enlargement of vegetative cells. The male sexual organ known as the *antheridium* (Fig. 128. a) contains a large number of *biciliate* male sexual cells known as the *spermatozoids* (Fig. 127. C). The female sexual organ, known as the *oogonium* (Fig. 128. b), contains the female sexual cell known as the *oosphere* (Fig. 127. B) which is a naked spherical mass of

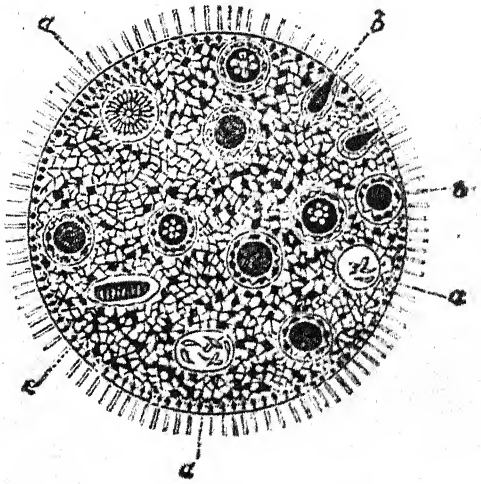


Fig. 128. *Antheridia* (a) & *Oogonia* (b) *of Volvox.*

protoplasm containing a nucleus. **Fertilisation :** The spermatozoids (male cells) are set free within the mother colony and gather about the oosphere (female cell) in swarms (Fig. 127. D). Finally, a single spermatozoid unites with the oosphere and the product of union is known as the *oospore* (Fig. 127. E). which covers itself with a two-layered wall and passes through a period of rest when it assumes a brick-red colour. **Germination :** The germination of the oospore takes place in the spring after its formation. At the time of germination, the outer coat of the oospore bursts and the protoplasm emerges surrounded by the swollen inner membrane. The mass of protoplasm at first divides into an eight-celled disk which is subsequently transformed into a Volvox-colony.

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**Order.** Confervales.

## Type : OEDOGONIUM (Green Algae).

(Figs. 129 & 130)

**Habitat & Microscopic structure:** The simple filaments of *Oedogonium ciliatum* can be found in rather still waters, attached to water-plants or bits of plant remains, or they may float in masses on the surface of the water. When young, the plants are generally attached by a special *rooting-cell* (Fig. 129. A) but they often break off and float when they are older. Each plant consists of a row of cylindrical cells, each slightly swollen at the top and having a *cell-wall* lined with *protoplasm* in which is embedded a *single chromatophore* which forms a sort of net-work and which contains *pyrenoids*. There in a *large nucleus* with a well-marked *nucleolus* in the protoplasmic lining. Close to some of the transverse walls, there are a number of fine parallel markings, which project at the edges so that the end of the cell appears to have a number of narrow *caps* (Fig. 129 B. c).

**Asexual reproduction:** In *Oedogonium ciliatum*, the *asexual reproductive cell* is formed from the entire contents of any cell of the filament. The protoplasm becomes rounded off and escapes through a slit in the wall near one end. It is surrounded by a very delicate transparent membrane and its more pointed colourless end is surrounded by a crown of delicate cilia by means of which it moves (Fig. 129. D). After swimming about for a few minutes, it comes to rest, settling on its colourless end. It loses its cilia, clothes itself with a wall and immediately proceeds to form a new plant. These motile bodies, which are known as *zoogonidia*, move in the direction in which the light falls upon them. If very strong, they move away from it, if of moderate intensity, they swim towards it. **Sexual reproduction:** The male sexual organ is known as the *antheridium* (Fig. 129 B. a) and the female sexual organ is known as the *oogonium* (Fig. 129 B. o). The antheridia and oogonia may be developed on the same plant or on different plants. Each *antheridium* consists of a *single cell*

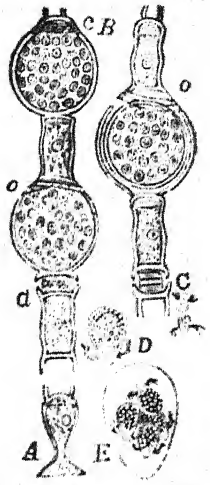


Fig. 129 *Oedogonium*. A—*Rooting cell* of the plant. B—Two plants with *antheridia* (a) and *oogonia* (o). C—Two *spermatozoids* with crown of cilia. D—A *zoogonidium*. E—A germinating *oospore* producing *four zoospores*.

which is similar to the other cells of the plant, except that the antheridial cells are shorter, and generally occur in series, one below the other. The contents of each antheridial cell generally divide into two parts each of which, when set free, forms a *multiciliate* motile body known as the *spermatozoid* which is similar to a zoogonidium, but smaller and paler (Fig. 129. C). Each *oogonium* is formed from a single cell of the plant which becomes ovoid, swollen and granular. The contents of each oogonium become rounded off to form the female cell known as the *oosphere* which contains a good deal of chlorophyll except at a certain point known as the *receptive spot*. Near the receptive spot, the wall of the oogonium opens in the form of a circular crack, a pore or a little lid. One of the spermatozoids enters into the oogonium through the opening and unites with the oosphere at the receptive spot; the product of union is known as the *oospore*. The oospore surrounds itself with a wall which gradually increases in thickness. Its colour changes to *yellow* or *red* and it becomes crowded with drops of oil. The oospore is set free by the decaying of the plant, including the wall of the oogonium. On germination, the outer wall is burst, and occasionally the contents grow out to form a new plant, but far more often it divides into *four* parts, which are set free as motile *zoospores* (Fig. 129. E), exactly similar to zoogonidia. Each zoospore swims about for a certain length of time, then comes to rest and grows out into a new plant which bears *asexual*, or sometimes *sexual*, organs.

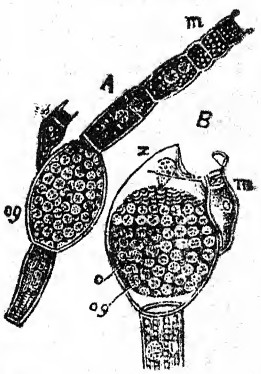


Fig. 130. *Oedogonium.* A—a plant with *three short cells* (m) and *oogonium* (og). B—a *dwarf male* plant (m) attached to the oogonium (og) containing the *oosphere* (o).

**Another kind of reproduction.**

In some species, termed gynandrosporous, the plant produces *no antheridia* but *only oogonia*. Some of the cells of such a plant undergo transverse division to form *short cells* (Fig. 130 A. m) which somewhat resemble antheridia. The contents of each of these cells are set free as a single *multiciliate zoospore*, termed an *androspore*, intermediate in size and colour between the ordinary zoospores and the spermatozoids, and resembling them in form. The androspore swims about for a certain length of time, then comes to rest, attaches itself to the wall of an oogonium (Fig. 130 B. og), germinates and forms a small filament, known as the *dwarf-male* (Fig. 130 B. m), which consists of a *root-cell and two or three* cells above it; each of the upper cells is an antheridium and its contents are set free as single *spermatozoid* which unites with the oosphere of an oogonium. The product of union is known as the *oospore* within which *four zoospores* are usually developed. The zoospores are set free by the bursting of the wall of the oospore and each of the zoospores develops into an Oedogonium plant.

—o—

**Order.** Confervales.

## Type : **ULOTHRIX** (Green Algae).

(Fig. 131)

**Habitat :** *Ulothrix zonata* occurs in clusters in shallow fresh water and in other places where the water is constantly renewed. It flourishes in cold weather, dying off in the summer. **Microscopic structure :** Each plant (Fig. 131.A) consists of a green unbranched thread which is generally attached by a somewhat pointed end to structures like stones, though sometimes it is found floating. Each plant is found to consist of a large number of cells which

are more or less alike excepting a colourless cell called *rooting-cell* (Fig. 131.A) which is tapering and by which the plant is attached to the substratum. The rooting-cell is occasionally branched. Each cell, excepting the rooting-cell, has a *thin layer of protoplasm* which contains the *nucleus* and a *band of chloroplastids* in which *pyrenoids* (Fig. 131A.py) are embedded. The growth *of the plant* takes place by the division of every cell.

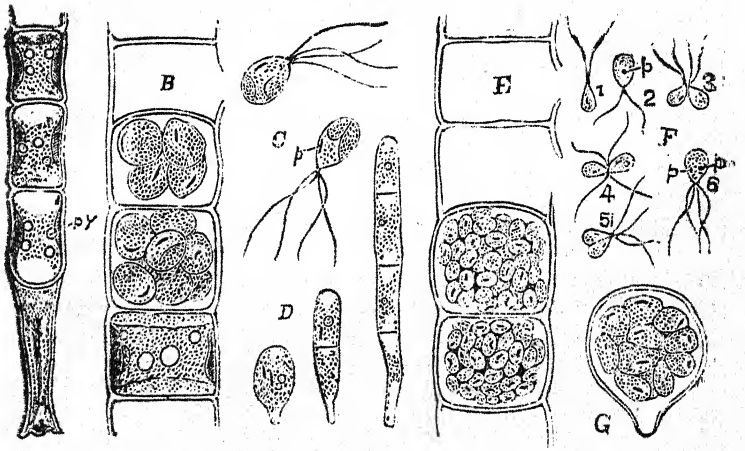


Fig. 131. *Ulothrix.*

*A*—Plant with the *rooting-cell* at the base and *pyrenoid* (py). *B*—Portion of the plant with a *vegetative cell* below and *two cells* which have formed *four* and *eight zoogonidia* respectively. *C*—A *zoogonidium* with the *red-spot* (p) and *four cilia*. *D*—Stages in the germination of a zoogonidum. *E*—Portion of a plant illustrating the formation of *gametes*. *F*—(1) A *biciliate gamete*; (2) A biciliate gamete with *red spot* (p); (3) Two biciliate gametes just *conjugating* by their pointed ends; (4) & (5) The conjugation of two biciliate gametes is more advanced; (6) The conjugation of two biciliate gametes is complete and the *zygospore* contains *two red-spots* (p) and *four* cilia. *G*—The *zygospore* with a thick-wall, *pointed end* and many *zoospores*.

**Asexual Reproduction :** Any cell of the plant may become an asexual reproductive organ when its pro-

toplasmic contents and nucleus generally become divided into *two* or *four* parts and sometimes into eight parts. Then a mass of protoplasm collects round each of these nuclei and thus a number of naked pear-shaped bodies called *zoogonidia* are produced within each cell. Each zoogonidium has a *mass of protoplasm,* a *nucleus,* a *chloroplastid,* a *red-spot* called *eye-spot* at one side (Fig. 131 C.p), *four cilia* at the pointed end and a *vacuole* which is rapidly expanding and contracting. The zoogonidia are set free by the rupture of the wall of the mother-cell and after swimming about for sometime by the movement of cilia, they come to rest, withdraw their cilia, fix themselves to some substance by their colourless ends, become clothed with wall and grow into new Ulothrix plants. (Sometimes the entire mass of protoplasm of a cell is set free as a zoogonidium).

Sexual Reproduction : Sexual reproductive structures are produced exactly like the asexual ones by the division of the nucleus of a cell into many parts and the subsequent collection of a mass of protoplasm round each of these nuclei. The sexual reproductive structures are *biciliate* (Fig. 131F.1 & 2) and in other respects they are exactly similar to the zoogonidia. These bodies are then set free by the rupture of the wall of the mother-cell and begin to swim about by the movement of cilia. When two of these bodies come near each other, their cilia become entangled (Fig. 131F.4) ; they first touch at their colourless pointed ends (Fig. 131 F.3) and gradually unite (Fig. 131F.5) to form a single body called *zygospore* (Fig. 131F.6). These motile bodies must therefore be regarded as *gametes* and the zygospore, which is the result of conjugation, is a motile cell with *four* cilia (Fig. 131F.6) and is distinguished from a zoogonidium by the possession of *two chloroplastids* and *two eye-spots* (Fig. 131F.6p). The zygospore moves about for sometime, then comes to rest, withdraws its cilia, fixes itself to some substance by its colourless end (Fig. 131G), becomes clothed with a

thick-wall and then enters on a period of rest through the summer months. Under favourable conditions of existence in autumn, the zygospore germinates and produces directly from its contents a number of structures called *zoospores* (Fig. 131.G) which are set free by the bursting of its wall. The structure of a zoospore is exactly similar to that of a zoogonidium but its mode of origin is different. (Sometimes if the gametes fail to conjugate, they may grow into new plants in the same way as the zoogonidia).

**Other forms of reproduction:** If the plant is in danger of drying up, it divides up into a number of thick-walled green bodies which enter on a period of rest and on the return of favourable conditions of existence, each of these bodies germinates into a new Ulothrix plant. If, on the other hand, the plant happens to lie under sufficiently damp conditions, it is divided into a number of green thin-walled bodies embedded in a jelly-like substance. These green bodies rapidly multiply by division and this form of Ulothrix very much resembles a plant called *Palmella* and hence the Ulothrix plant is said to have assumed a "Palmelloid condition."

—x—

**Order.** Conjugales.

## Type: DESMIDS (Green Alage).

(Fig. 132)

**Habitat:** These are fresh water plants. **Microscopic structure:** These plants are unicellular and generally live isolated, less frequently in rows which readily break up into separate cells. Each cell consists of a *mass of protoplasm*, a *nucleus*, two or more *chloroplastids* containing *pyrenoids* (Fig. 132. B (1) & C). **Vegetative Reproduction:** The Desmids multiply to a large extent by *division*. Each cell divides into

*two* by a wall in the plane of symmetry or within the constriction when there is one; this wall splits up into two parts and thus the halves are separated (Fig. 132. A, B (1) & C). A new half grows out from each half at the place of separation (Fig. 132. B 2) and a new plant is thus produced. Thus the *two halves* of a plant *are of different ages.*

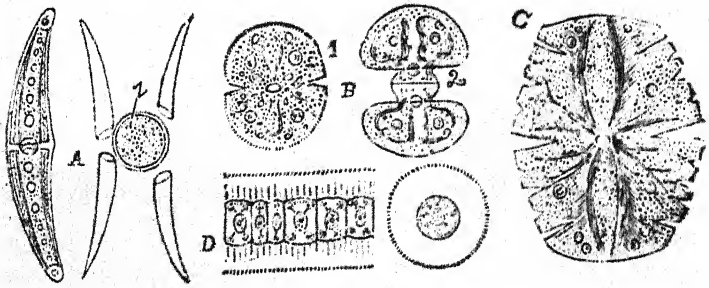


Fig. 132. *Desmids.*

*A*—A desmid (*Closterium*); at the left there is the *plant* and at the right there is a *zygospore* (z) between the halves of two empty plants whose contents have fused. *B*—A desmid (*Cosmarium*); (1)—the plant; (2)—the plant which has just divided and is forming two new parts between the old halves of the parent plant. C—A desmid (*Micrasterias*) which is very elaborate in its outlines and markings. D— *Hyalotheca*) which is a common filamentous desmid; the appearance of the cells in face view is shown at the right.

**Sexual Reproduction :** The other mode of reproduction of Desmids is by *conjugation.* Each of the two conjugating plants puts out towards the other a *conjugating process* and the two processes meet and each expands into a hemispherical bladder. The wall that separates the conjugating processes disappears and the contents of the conjugating cells unite in the broad canal thus formed. The zygospore (Fig. 132 A. z), thus produced, either germinates directly or its contents produce two or more daughter-cells, each of which multiplies by division.

—o—

**Order.** Conjugales.

## Type : SPIROGYA (Green Algae).

(Fig. 133).

**Habitat:** These are common thread-like Algae which grow in slimy masses at the top of stagnant water, in ponds, streams with a very slow current and in other similar masses of water. **Microscopic Structure:** Each plant is composed of similar cylindrical cells joined end to end showing *no distinction between base and apex.* Each cell of a well-developed plant is composed of (1) a *wall* covered with a thin gelatinous sheath; (2) a *thin layer of protoplasm* attached to the cell-wall; (3) a *central mass of protoplasm* containing the *nucleus* and the *nucleolus*; (4) *vacuoles,* crossed by delicate protoplasmic strands of cells connecting the central mass of protoplasm with the protoplasmic layer in contact with the cell-wall; (5) *spirally coiled chloroplastids* (Fig. 133 A. s) which lie in the layer of protoplasm attached to the cell-wall. Numerous colourless structures called *pyrenoids* (Fig. 133 A. p) occur in each chloroplastid. Each pyrenoid is mainly composed of proteins surrounding starch grains.

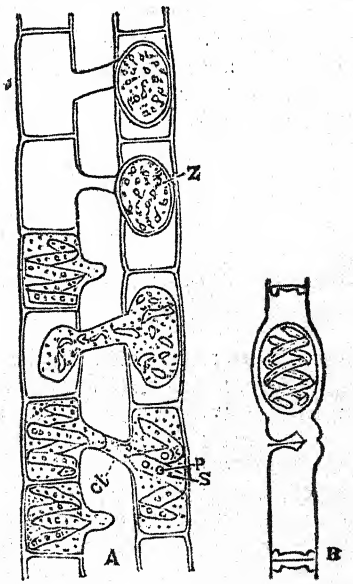


Fig. 133. *Spirogyra.*

*A*—Illustrates *stages in conjugation*; *conjugating tube* (ct), *spiral band of chloroplastid* (s) containing *pyrenoids* (p); two *zygospores* shown above. *B*—Illustrates conjugation between adjacent cells of the same plant.

**Vegetative Reproduction :** Each plant may break up into cells or into similar pieces, each being composed of a few cells. These divide and form fresh plants. This mode of reproduction, which is purely *vegetative*, takes place comparatively rarely. **Sexual reproduction :** Under favourable conditions of growth, the plant reproduces itself sexually. In this process, two plants lie side by side and send out small tube-like structures called *conjugating tubes* from opposite cells. The conjugating tubes meet with each other by gradually increasing in length, the cell-walls at the points of contact are then absorbed and a free communication is then established between the cells. The contents of each cell constitute a *gamete* (sexual mass of protoplasm) and the cell bearing a gamete is known as the *gametangium*. Then a gamete of one plant passes through the conjugating tube and unites with the gamete of the other plant. The product of union is known as the *zygospore* which covers itself with a many-layered wall. Under favourable conditions of germination, the zygospore germinates and gives rise to a Spirogyra plant. (Note : The gametes which move down the tubes may be said to be *male*, the gametes which receive the male gametes are the *female*. Usually all the gametes of one plant pass over into the other plant, so that the plants are unisexual; but sometimes conjugation takes place between the gametes of the same plant, the contents of one cell entering into the other. (Fig. 133. B).

Sometimes when conjugation fails to take place, the gametes contract into bodies called *azygospores* which are said to be formed *parthenogenetically*. Each azygospore may germinate like a zygospore and a Spirogyra plant may be developed from it. (Note : *Parthenogenesis* is the process by which a sexual cell develops into the normal product of fertilisation without a preceding sexual act. The gametes (sexual cells) of Spirogyra, without sexual union, may be converted into azygospores which develop into new plants).

**Order.** Diatomales.

## Type: **DIATOMS** (Green Algae).

(Fig. 134).

**Habitat:** These plants are present in both fresh and salt water. **Microscopic structure:** These *unicellular* plants occur either free (Fig. 134. A,E, F) or connected into filaments or masses by mucilage (Fig. 134. C. D); sometimes these plants are attached. Each cell (plant), called *frustule,* consists of two halves, called *valves* (Fig. 134A.2) of different ages, which are not directly continuous but are related to each other as the two parts of a pill-box, the one overlapping the other. The cell-contents consist of a more or less *vacuolated mass of protoplasm* which forms a layer in close contact with the inner surface of the cell-wall; in this, there is a *nucleus* and *chromatophores,* which may be one or more, in the form of relatively

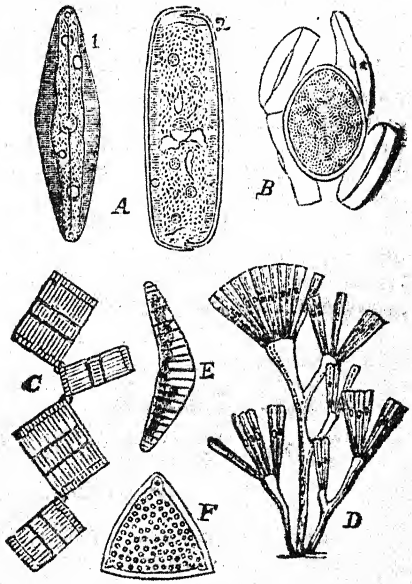


Fig. 134. *Diatoms.*

*A*—The boat diatom (*Navicula*); (1) is the front view and (2) is the side view showing the two *overlapping valves*. *B*—Two diatoms (*Acnanthes*) whose contents have united to produce the sexually formed spore (*auxospore*) and whose four empty shells are seen. *C*—Groups of diatoms (*Tabellaria*) have united with one another to form a zigzag filament. *D*—Groups of diatoms borne on gelatinous stalks. *E*—Diatom (*Epithemia*). *F*—Diatom (*Triceratium*).

*large* plates. Vegetative reproduction: *Vegetative multiplication* by *division* takes place by the division of the protoplasm into two cells, each of these cells has one of the two valves of the parent cell on one side of it; it then secretes a new valve on its naked side which is smaller than the older valve and fits inside its rim; thus two new individuals are formed. This process of multiplication is accompanied by a decrease in size; and if it is repeated indefinitely, the cells would become smaller. This process of diminution is interrupted by the formation of *auxospores*, either *asexually* or *sexually*. In the *former* case, the protoplasmic contents of a cell (plant) escape from the separated valves, as an *auxospore*, which after growing considerably, stretches two new valves forming a new and larger plant. In the *latter* case, two naked masses of protoplasm which have escaped from the separated valves, conjugate to form an *auxospore* (Fig. 134 B) which becomes a new plant.

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**Order.** Siphonales.

## Type: VAUCHERIA (Green Algae).

(Figs. 135 & 136).

Habitat: *Vaucheria sessilis* is a common green Alga living in fresh water and in damp places. A few live in brackish water. Microscopic structure: The body of the plant consists of much branched tubular threads (Fig. 135E). The plant, when growing on damp earth, is fixed to it by a peculiar colourless structure called *root-process* (Fig. 135 E.h). The body of the plant is *coenocytic* because it consists of a continuous tube without any transverse wall and is made up of a large number of protoplasmic masses containing *nuclei*. The wall of the tube is lined with a *layer of protoplasm* in which are embedded a *large number of chloroplastids* and *numerous drops of oil*; the centre of the tube is occupied by a *vacuole* which is

filled with cell-sap. *The growth of the plant* takes place by the elongation of the tips. **Vegetative Reproduction:** When the plant is in danger of being dried up, its body is divided into a number of parts by transverse walls. The protective condition is known as the *gongrosira condition*. Each of these parts grows up into a new plant when favourable conditions of existence return. **Asexual Reproduction:** When the plant is about to develop asexual reproductive organs, the tips of some of the branches become swollen (Fig. 135 A) and the contents of the tips become cut off from the rest of the body

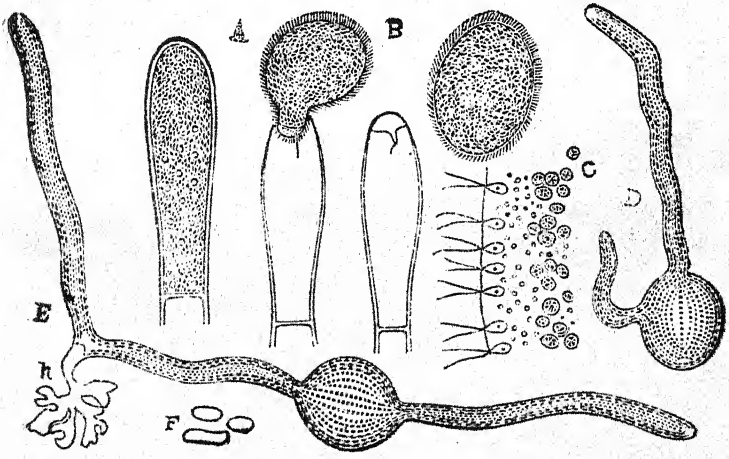


Fig. 135. *Vaucheria.*

*A*—Left and right figures show *formation* and *discharge* of a *multiciliate zoogonidium* from an opening at the tip of a *zoogonidangium*. *B*—The *zoogonidium* showing the *multiciliated* surface at the right and the *skeleton of the zoogonidangium* at the left. *C*—Section through the *surface of the zoogonidium* showing the *pairs of cilia* above the nuclei and the layer of plastids beneath. *D*—*Germination of the zoogonidium*. *E*—Young *Vaucheria* plant, the two filaments having arisen at opposite ends of the zoogonidium, one having developed an organ of attachment or *root-process* (h). F—A group of *plastids*.

of the plant by *transverse wall* (Fig. 135. A). The contents of each of the tips contract from the wall and thus a multiciliate body having many nuclei is formed. Each of these bodies is called a *zoogonidium* and the structure in which a zoogonidium is developed is known as *zoogonidangium* (Fig. 135. A). The *zoogonidia* are set free by the bursting of the tips of the zoogonidangia (Fig. 135. B). The zoogonidium may be broken into two parts at the time of squeezing itself out through the opening of the zoogonidangium. On coming out of the zoogonidangium, the zoogonidium swims about for sometime and while still in motion, forms a wall through which the cilia protrude. The zoogonidium then comes to rest, withdraws its cilia and grows into a new Vaucheria plant (Fig. 135. D & E).

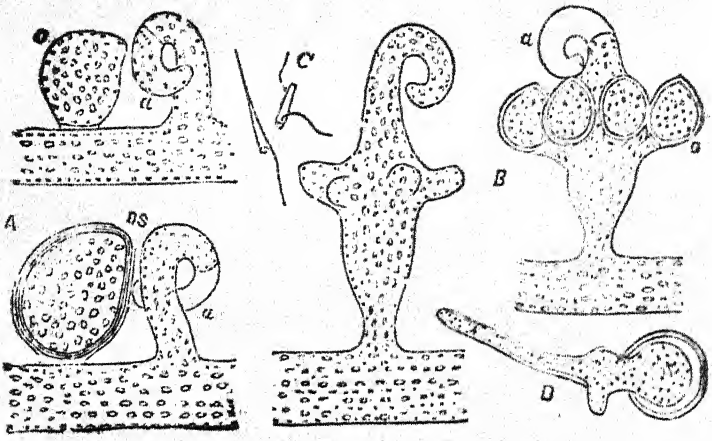


Fig. 136. *Vaucheria.*

*A—Upper figure* showing *oogonium* (o) and *antheridium* (a); *lower figure* showing *oospore* (os) with a thick wall and the skeleton of an antheridium beside it. *B*—A short lateral branch from the body of the plant has developed *four oogonia* and an *antheridium* (a) which has discharged its contents. *C*—Biciliate *spermatozoids. D—Germinating oospore.*

**Sexual Reproduction :** The sexual reproductive organs are either formed on short branches or they take the place of short lateral branches. The branch forming the female sexual organ, called *oogonium* (Fig. 136 A. o) becomes swollen and all the nuclei in it except one pass into the body of the plant. The contents of the oogonium are then cut off by a wall from those of the body of the plant and become the female gamete called *oosphere* which is rich in chlorophyll and oil-drops. At the tapering end of the oogonium there is a clear spot called the *receptive spot.* The male sexual organ called *antheridium* (Fig. 136 A. a) is developed near the oogonium. Its tip becomes curved and is cut off by a transverse wall. The antheridium is multinucleate and from its nuclei and a portion of the protoplasm, the male gametes called *spermatozoids* (Fig. 136. C) are formed. The spermatozoids are *biciliate* and are set free by the bursting of the tip of the antheridium. **Fertilisation :** At the time of the maturity of oogonium, a mucilaginous substance is excreted through an opening at the receptive spot and the spermatozoids are attracted by the smell of this substance. One spermatozoid at last enters into the oogonium through the receptive spot and unites with the oosphere. The *oospore* (Fig. 136 A. os), which is the result of the fertilisation of the oosphere by the spermatozoid, then develops a thick wall and undergoes a period of rest when its colour changes from dark-green to red or brown. Under favourable conditions of existence, the oospore germinates (Fig. 136. D) and grows up into a Vaucheria plant.

—o—

**Order.** Charales.

## Type : CHARA (Green Algae).

(Figs. 137, 138 & 139).

**Habitat :** These plants form close patches at the bottom of fresh-water and brackish lakes, ditches and streams ; some grow in deep water, some in

shallow, some in stagnant water and some in rapid streams; perennial species grow intermixed with annual. **Morphological structure**: The body of the plant is differentiated into *root, stem* and *leaf*. The **roots**, with the exception of the first root of the embryo, are all adventitious. The stem (Fig. 137A) is distinctly segmented into nodes and internodes, the nodes being marked by the whorls of leaves which they bear; **secondary leaves** (secondary rays) are also developed from the primary ones. **Branches** are developed as buds in the axil of one or more leaves in each whorl. **Microscopic structure**: The internodes of the stem consist of a longitudinal series of elongated cylindrical cells separated from each other by transverse plates of small cells at the nodes. Each internode is covered by **cortex** which consists of rows of cells, sometimes spirally twisted, produced by the growth of the peripheral cells of each node, both upwards and downwards. All the cells contain small chlo-

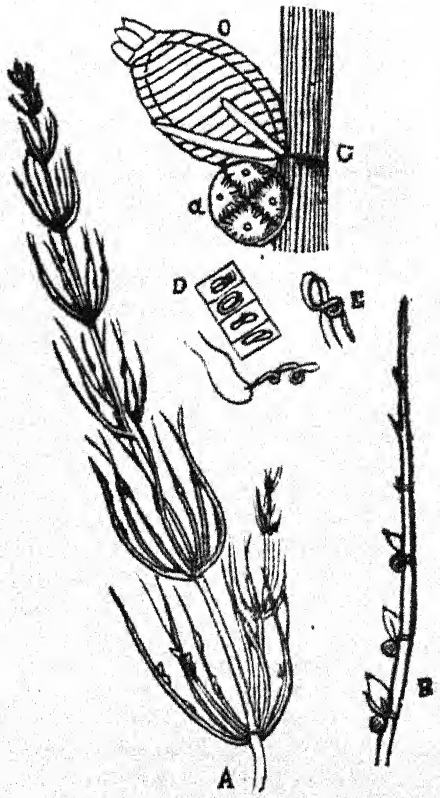


Fig. 137. *Chara.*
*A*—A portion of the plant showing cir-

cles of *lateral leaves* at the nodes. B—A magnified view of a *lateral leaf bearing* the *sexual* (*male and female*) *organs*. C—A magnified view of *a portion of a leaf bearing the male and female sexual organs ;* the female organ, *oogonium* (o), consists of spirally wound filaments which form a *crown* at the top ; the male organ, *antheridium* (a), is composed of flattened cells (*shields*). *D*—A portion of an *antheridial filament*, each cell of which bears a male cell, *spermatozoid ; E*—Two *biciliate spermatozoids*.

roplastids which lie embedded in the protoplasm immediately beneath the cell-wall. The more internal portion of the protoplasmic layer shows the movement known as *cyclosis*. The central portion of the cell, when the cell is fully grown, is occupied by *a large vacuole* filled with cell-sap. Each cell contains *a single nucleus*, when young ; but the long internodal cells, when old, are found to contain *many nuclei* by the division of the original nucleus. The sexual organs are in all cases borne on the leaves (Fig. 137.B). The plant may be either monoecious or dioecious. The antheridium or *globule* (male, Fig. 137 C.a) is a spherical body, of a green colour when young but orange when mature, borne on a stalk (Fig. 138 a.p). Its wall consists of *eight* cells (Fig. 138.a), each of which is termed a *shield*. On the inner surface of each shield, is attached a cylindrical cell, the *manubrium* (Fig. 138 a.m), which extends to near the centre of the antheridium. Each manubrium bears at the end a somewhat spherical cell called the *capitulum*. To each capitulum are attached usually *six* rounded cells, the *secondary capitula*. Connected with each secondary capitulum are *two* cells, each of which bears *a pair of long filaments*, each filament consisting of about *two hundred* cells. Each cell of the filament gives rise to a *single spermatozoid* which consists of a club-shaped

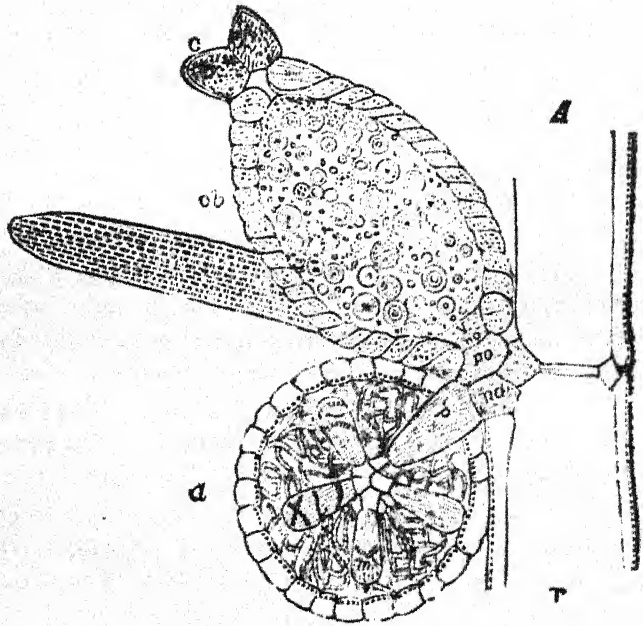


Fig. 138. *Chara*.

r—Magnified view of a portion of a leaf bearing *antheridium* (a) and *oogonium* (ob). The *antheridium* (a) is borne on a *stalk-cell* (p) which is situated on a *nodal cell* (na), the *manubrium* (m) is situated inside the antheridium. The *oogonium* (ob) is situated on a *nodal cell* (no), and an internodal *stalk-cell* (pa) ; the *corona* (c) of the oogonium.

spirally wound mass of protoplasm bearing *two long cilia* at its pointed end. When the antheridium is mature the shields separate, the spermatozoids are set free from their mother-cells and escape into the water. The oogonium or *nucule* (female, Fig. 138. ob) is of ellipsoidal form. Beneath the oogonium is a node the central cell of which constitutes the *stalk* (Fig. 138. pa) whilst the *five* peripheral cells of the node grow out into filaments which gradually become spirally twisted and enclose the oogonium; the tips of those filaments project at the free end of the oogonium, constituting the *corona* or *crown* (Fig. 138. c). The five enveloping tubes are *rich in chlorophyll* and form the *neck* which encloses a narrow cavity, the *apical cavity*, which is closed above by the crown. The female cell, *oosphere*, lies within the cavity of the oogonium. At the time of fertilisation, five lateral fissures appear between the neck portion of the five tubes and thus an opening is made to the outside; through these fissures the spermatozoids find an entrance into the apical cavity which is filled with a mucilaginous matter, and make their way to the oosphere. One of the spermatozoids unites with the oosphere; the product of union is known as the *oospore* which clothes itself with a wall of cellulose. The chlorophyll-corpuscles of the five enveloping tubes assume a reddish-yellow colour and the walls of the enveloping tubes adjacent to the oosphere assume a black colour. The oospore then falls to the ground

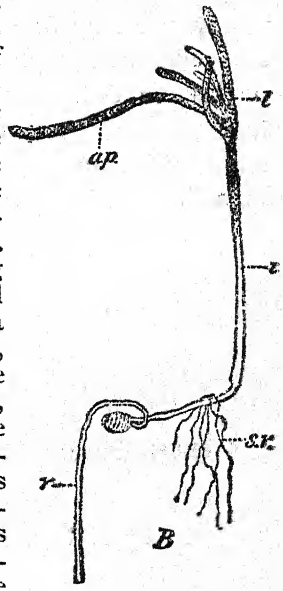


Fig. 139. *Chara.* Apical portion of the shoot (ap); leaves (l); adventitious roots (sr) and primary root of embryo (r) springing from the oospore.

to germinate in the ensuing autumn or in the next spring. The oospore, on germination, does not produce a *sexual leafy plant* at once. It divides into two cells, one large called the *basal cell* and one small called the *nodal cell.* The basal cell contains reserve food material and the nodal cell divides into *two* cells, each of which develops into a tube. One of these tubes is the so-called *primary* or *main root* (Fig. 139. r) and the other the *pro-embryo* (Fig. 139. ap & l), from which the plant is subsequently formed.

—o—

**Class.** Phaeophyceae.

## Type : **FUCUS** (Brown Algae).

(Figs. 140 & 141).

Habitat : *Fucus vesiculosus* grows on rocks between the tide marks. Morphological structure : The body of the plant contains *air-bladders* (Fig. 140 A. b) which enable it to float and which explode when the plant is trodden upon. The body of the plant consists of a rooting portion known as a *hold-fast* (Fig. 140 B. h), an irregular flattened disc which secures it most firmly to the rock but which is not a root for it has

no absorptive function. There is a stem-like portion which is more or less cylindrical. The greater part of the plant consists of a flattened, much branched thallus, the midribs of the branches being stronly marked. The "stem" is formed by the midrib of the lower part, the wings having become worn off. The *branching is dichotomous* (Fig. 140. A). though at each forking there is a tendency for one branch to become more strongly developed than the other. The whole surface, except that of the midribs, is covered by a number of dots. These

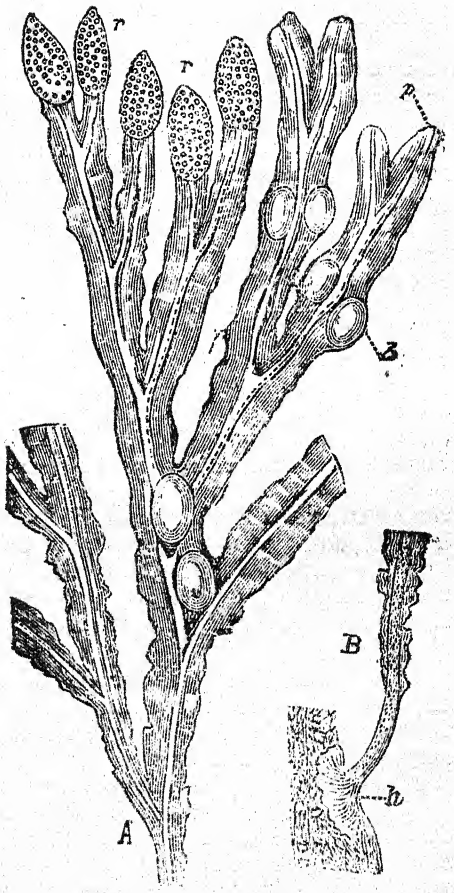


Fig. 140. *Fucus.*

A—Plant showing *dichotomous branching*; air-bladders (b); pit (p) at the growing-point; swollen tips with the sunken cavities known as *conceptacles* (r) which contain the *sexual organs.*

B—Base of the plant with the *hold-fast* (h).

are the mouths of small cavities lined and *fringed with hairs*. These markings are specially well developed towards the ends of certain branches, which are frequently swollen. These swollen branches are the fertile branches, the more conspicuous dots leading to the *fertile conceptacles* containing sexual organs (Fig. 140 A. r) in addition to the hairs which are also found in the smaller "sterile conceptacles". The growing-point lies in a groove (Fig. 140 A. p) near the ends of the branches. **Reproduction:** The male and female organs occur on different plants of the same species; they are borne in the same conceptacle. The conceptacles appear to originate as depressions on the surface of the thallus. A section through a **male conceptacle** shows the following structures—Numerous *much branched hairs* proceed from the lining of the conceptacle. Hairs are also found at the small entrance to the conceptacle. The male reproductive organs, the *antheridia* (Fig. 141. D), are borne on the branches of the hairs lining the cavity of the conceptacle. Each antheridium is unicellular, with a double-layered wall. As it ripens, its contents divide up into a number of portions, each containing one or two orange-coloured chromatophores. The hairs of the conceptacle excrete a mucilage.

When the tide goes out, and the plants are left exposed, the mucilage exudes from the opening of the conceptacle as an orange-coloured mass, which carries with it the antheridia. The outer layer of the wall of the antheridium bursts as the tide comes in and the *spermatozoids* (Fig. 141 E.) are set free by the rupture of the inner wall. Each spermatozoid has *two unequal cilia* placed laterally, the shorter one being nearer the pointed end. The spermatozoids swim freely in the rising tide. A section through a **female conceptacle** shows a number of female organs (*oogonia*) between which there are a number of sterile hairs known as *paraphyses* (Fig. 141 A & B). A mature oogonium contains *eight oospheres* (female cells). The oogonium is set free from its unicellular

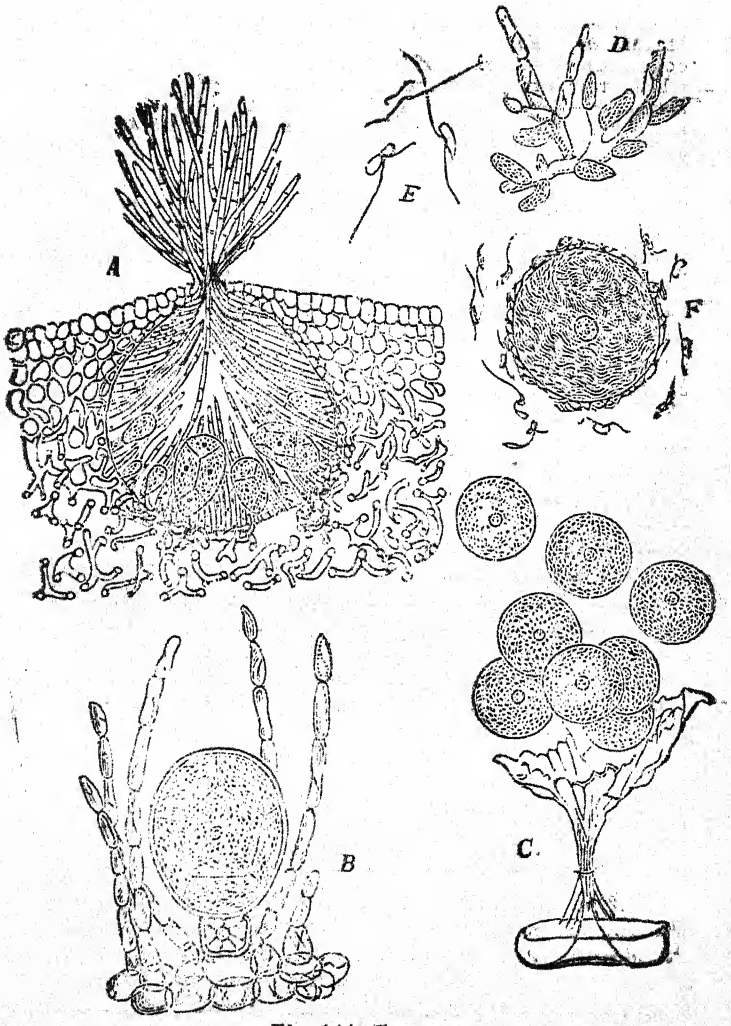


Fig. 141. *Fucus.*

A—Section of a *female conceptacle with oogonia* showing the *hairs* which project through the opening into the water and the

loose *net-work of filaments* in the interior of the plant. B—Mature *oogonium*. C—The *discharge of eight oospheres* from an oogonium. D—A *group of antheridia* on the branching filaments which grow intufts over the sides and bottom of the *male conceptacles*. E—Very highly magnified *spermatozoids* with *two cilia* at the side. F—An *oosphere* lying free in the water and surrounded by *spermatozoids*.

stalk, and like the antheridium, escapes in a drop of mucilage through the mouth of the female conceptacle. The wall of the oogonium bursts and the *eight uninucleate oospheres* (Fig. 141.C) are set free into the water with the rising tide. The oospheres are non-ciliate and hence non-motile. **Fertilisation:** The spermatozoids, attracted by some chemical substance, swarm round the oospheres (Fig. 141.F) and the lashing movement of their cilia causes the oospheres to rotate. This goes on for about a quarter of an hour and then the oosphere unites with one of the spermatozoids and comes to rest. The product of union is known as *oospore* which clothes itself with a wall and almost at once begins to germinate. The end by which the oospore is attached to the rock becomes pear-shaped, and is separated off from the rest by a transverse wall. It soon becomes branched, and forms the rooting portion (hold-fast). The remainder of the oospore grows directly into the shoot of the young *Fucus* plant.

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**Class.** Rhodophyceae.

## Type : POLYSIPHONIA (Red Algae).

**Habitat:** The *Red Algae* prefer warmer waters and are abundant on the coasts of the Mediterranean, the islands of the West Indies, Southern California and Australia. They generally flourish in deeper waters than the *green* and *brown* Algae; some of the forms are found at depths of two hundred feet or more. Most of the Red Algae seem to prefer shaded

situations among the rocks and some types are incrusted with lime and form the curious growths on rocks called *corallines*. **Microscopic structure :** The body of these plants consists of rows of cells, called *siphons*, connected with one another in an elaborate manner. The *sexual organs* are developed on separate plants. The male organs, *antheridia* (Fig. 142 A), are modified branches that develop an outer covering

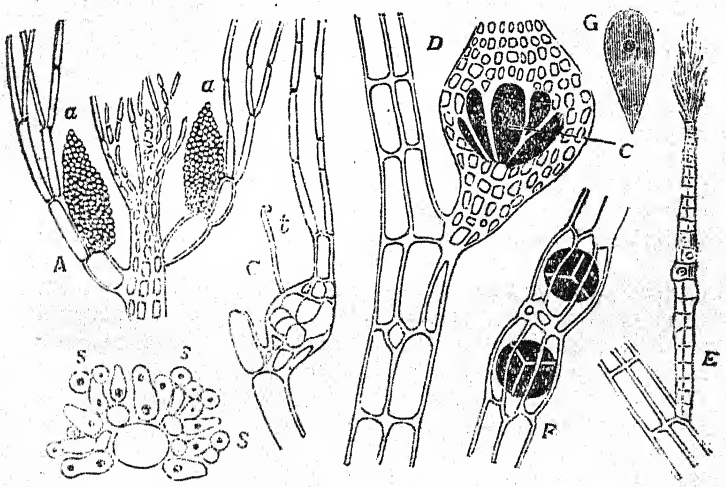


Fig. 142. *Polysiphonia.*

A—Tip of filament showing *two antheridia* (a) ; S—Cross section of a portion of an antheridium illustrating the development of the *spermatia* at the ends of the very numerous short branches ; C—A *procarp* with the projecting *trichogyne* (t) from the female cell (carpogonium) which is hidden by the surrounding sterile cells; D—Mature *cystocarp* with an envelope enclosing a cluster of *carpospores ;* G—A *carpospore ;* E—A short branch from a *tetrasporic plant ;* F—*Two groups of tetraspores* from a plant similar to E ; note the peculiar arrangement of the tetrasporesi n a group of four or *tetrad.*

of small cells which form the male cells known as *spermatia* (Fig. 142. S). The female organ, *procarp* (Fig. 142. C), is found on a small branch and consists of a basal portion known as the *carpogonium* and an upper portion known as the *trichogyne* (Fig. 142 C.t), accompanied by a number of vegetative cells. One of the spermatia unites with the trichogyne (Fig. 142 C.t) and thus the carpogonium is fertilised. The fertilised carpogonium is known as a *cystocarp*. There are two sets of activities concerned with the development of the cystocarp : (1) the neighbouring cells, known as the *auxiliary cells*, unite with the fertilised carpogonium and supply nourishment to it ; then certain spores, known as the *carpospores*, are developed within the fertilised carpogonium ; (2) some vegetative cells round the carpogonium give rise to an envelope which protects the carpospores (Fig. 142. D & G). The cystocarp of *Polysiphonia* is therefore a system of two tissues, one derived from the fertilised carpogonium and the other from the vegetative cells of the parent plant. Besides the sexual plants (male and female) there is an *asexual condition in Polysiphonia* called the *tetrasporic plant* (Fig. 142 E). Tetrasporic plants are individuals which develop asexual spores, called *tetraspores*, in groups of *four* termed *tetrads* (Fig. 142. F). The tetraspore-mother-cells arise from the central siphon near the ends of the branches. Some recent investigations clearly indicate that the tetrasporic plants are developed from carpospores and that the tetraspores develop into sexual plants. So there is an *alternation of sexual and tetrasporic plants* in the life-history of Polysiphonia.

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# FUNGI.

## Class. SCHIZOMYCETES or Bacteria.

**General Description:** The *bacteria* are the smallest living beings known. The single cells of many species are less than one ten thousandth of an inch in

diameter and some are very much smaller still. Most of the bacteria are *one-celled.* Some types are spherical or oval (*Coccus form,* Fig. 143. 5, 6 & 7), some are straight or slightly bent rods (*Bacterium form,* Fig. 143. 2), some are of spirally twisted forms of various lengths (*Spirillum form,* Fig. 143. 3 & 4), some are straight free filaments (*Bacillus form,* Fig. 143. right to 3), or the individuals may form cubical masses (*Sarcinae,* Fig. 143. 1). The bacteria are present almost everywhere floating in the air on particles of dust, in the water, in the soil, and always living within and upon the bodies of animals. Some forms are restricted to a *parasitic life* on particular hosts, as certain animals or plants or man. Other types are connected with special *chemical reactions,* as in the processes of fermentation, nitrification etc. Many bacteria are indispensable to life on the earth and of the greatest service to man. Many forms are harmless, but of no special value to man. Some cause dangerous contagious diseases e. g. diphtheria, typhoid fever, tuberculosis, cholera, pneumonia, influenza etc. **Microscopic Structure:** Each cell consists of a *mass of protoplasm,* which is generally colourless, though occasionally it may contain pigments like green, red, blue etc. The protoplasm is surrounded by a *membrane* which sometimes appears to consist of protein material, sometimes of cellulose. The wall is often coloured, and it is due to this that patches of these organisms

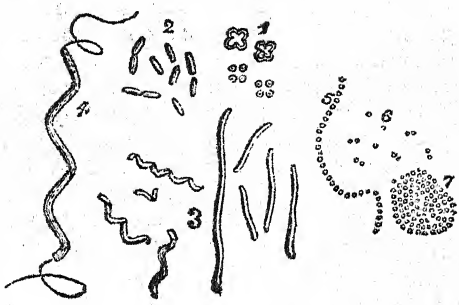


Fig. 143. *Bacteria.*

1—*Sarcinae;* 2—*Bacteria;* 3—*Spirilla;* 4—*Spirillum* showing cilia; 5. 6, 7—*Micrococci in* strings, singly and in groups.

often form bright coloured spots on decaying material. It is not certain whether they contain a *nucleus*. There appear to be one or more bodies which take up nuclear stains; these "chromatin grains" may represent a rudimentary nucleus. One or more *vacuoles* may sometimes be distinguished. Many forms of bacteria are capable of movement. The movement may be merely an oscillatory one due to the action of the whole cell, or it may be due to the action of cilia (Fig. 143. 4). There may be one or two cilia, or the whole surface may be more or less clothed with these threads, which in many cases seem to be prolongations of the wall, and not portions of the protoplasm. **Reproduction:** The most common mode of reproduction is by *simply splitting apart;* each cell splits into two. Many bacteria also reproduce themselves by developing thick-walled resting cells, or *spores,* within the parent cell, which can survive a temperature above the boiling-point of water and also below freezing, and are able to live for very long periods. **Typical life-history of a form of Bacteria** e. g. *Bacillus subtilis :* This form can be seen in infusions of hay when allowed to stand. At first the organisms move actively by means of cilia (*motile form*) ; after this the cells cease to be motile and remain connected into filaments (*bacillus form* ; then a membraneous scum forms on the surface of the liquid (*zoogloea form*) ; at this stage *spore-formation* begins and the life-cycle is at an end. The spore gives rise, on germination, to the motile form and so the life-cycle is repeated.

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## Class: MYXOMYCETES.

**Habitat:** These organisms are mostly saprophytes living on decaying organic substances, such as decaying leaves, tree stumps etc. **General Description:**

The Myxomycetes are divided into two groups—*Endosporae* and *Exosporae*. In the **Endosporae**, the spores are found within the wall of the sporangium. In the **Exosporae**, the spores are not found in the interior of the sporangium, but by abstriction from the ends of filaments developed from the surface of the stalk of the sporangium. **Microscopic Structure**: There are generally *four* stages in the life-histories of the Myxomycetes. The stages are—(1) *Mastigopod stage*, (2) *Myxopod* or *Amoeboid stage*, (3) *Plasmodium stage*, and (4) *Spore-formation stage*. In the Mastigopod stage, the contents of each spore escape, on germination, as a *zoospore* which is a naked mass of protoplasm provided with a *cilium* and enclosing a *nucleus* and

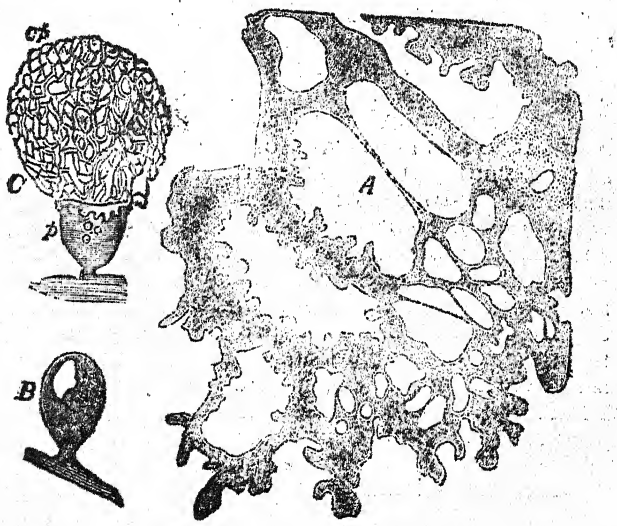


Fig. 144. *Myxomycetes.*

A—*Plasmodium*; B—A *Sporangium* on a stalk (*sporophore*); C—A *Sporangium* after the rupture of its *wall* (p) and expansion of the *capillitium* (cp).

*a contractile vacuole.* In this stage, each cell multiplies by division. In the **Myxopod** or **Amoeboid** stage, each zoospore, after swimming about for sometime, withdraws its cilium and creeps about by means of temporary protrusions of its protoplasm termed *pseudopodia.* In this stage also, multiplication by division takes place. In the **Plasmodium** stage, the masses of protoplasm (*amoebae*) formed in the *Myxopod stage* collect together into a mass known as the *plasmodium* (Fig. 144) but there is no fusion of the nuclei of the constituent masses of protoplasm so that the plasmodium is multinucleate. The plasmodium creeps about by means of pseudopodia (temporary protrusions of its protoplasm) until spore-formation begins. In the **Spore-formation** stage, the plasmodium comes to rest and forms either a single *sporangium* (Fig. 144 B) or divides into several portions each of which forms a sporangium. The external portion of the mass of protoplasm hardens to form the *wall* of the sporangium while the internal portion after rapid nuclear division, separates into cells each of which produces a proper wall and becomes a *spore.* In many cases, the sporangium has a stalk known as the *sporophore* which is sometimes continued into the cavity of the sporangium as the *columella.* In most forms, a portion of the internal protoplasm goes to form a number of filaments, either free or connected into a network, which constitute the *capillitium* (Fig. 144C. cp). The sporangium-wall and capillitium give the reactions of cuticularised cell-wall.

Uncommon forms.

(1) In some forms, a compound sporangium, termed *Æthalium*, is formed by the combination of a number of plasmodia.

(2) In some forms, the mastigopod stage is wanting, the spores directly passing into the *amoeboid* or *myxopod stage* during which a number of amoebae are produced.

(3) The mastigopods or the amoebae may, without producing the plasmodium, surround themselves with a wall and go through a resting stage as *microcysts*; or the whole or part of a plasmodium may do the same as a *sclerotium*.

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## Class: Phycomycetes.

### Sub-Class: Zygomycetes.

### Type: **MUCOR*** (C. U. 1909, 1910, 1918).

Habitat. Mucor mucedo is a saprophytic fungus which grows on substances like ripe fruit, jam, bread etc. when kept warm and damp. **Microscopic Structure:** The body of the plant consists of a much branched tube without any cross-wall or with a few irregular ones; the net-work of branched tubes is known as the *mycelium* (Fig. 145 & 146 m.) and each tube is called a *hypha*. The hyphae contain *protoplasm, a large number of nuclei, vacuoles* and *oil-globules*. **Asexual Reproduction:** Some hyphæ grow vertically up in the air from the mycelium and look like small round-headed pins which are called the *sporangia* (Fig. 145 & 146. s). Each *sporangium* is a swelling at the tip of a hypha cut off from the rest of the mycelium by a wall which subsequently projects into the *sporangium* forming what is known as the *columella* (Fig. 145 & 146 c). The lower portion of the hypha upon which the *sporangium* is situated is known as the *sporangiophore* (Fig. 145 & 146. l). The contents of the *sporangium* become divided into a large number of multinucleate masses of protoplasm which become subsequently clothed with cell-walls and are then known as the *spores* (Fig. 145 & 146. sp). The wall of the *sporangium* bursts and the *spores* are then set free from the *sporangium*. The remains of the wall of the *sporan-*

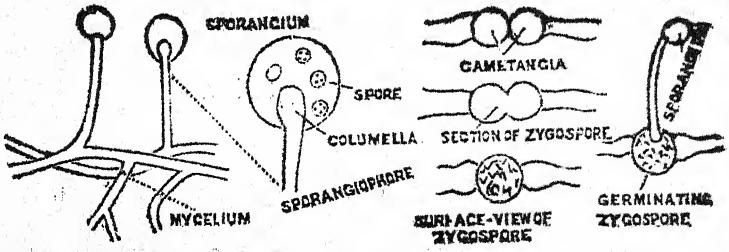


Fig. 145 *Mucor.*

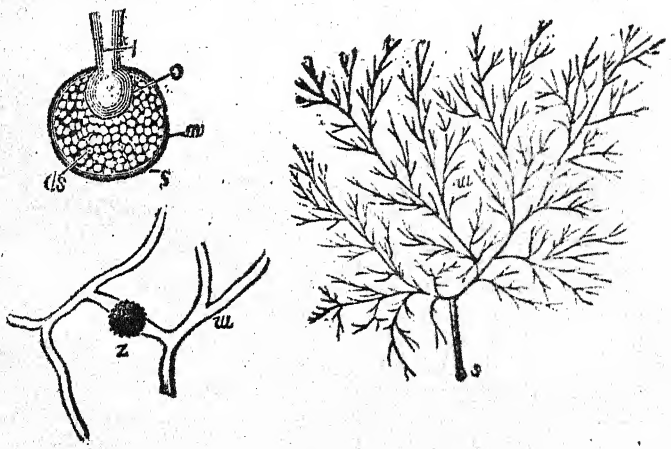


Fig. 146 *Mucor.*

s—*Sporangium* ; m—*mycelium* ; z—*zygospore* ; sp—*spores* ; w—*wall* of the sporangium ; c—*columella* ; l—*sporangiophore.*

*gium* now look like a cup at the top of the *sporan-*

*collar*. Each *spore*, on falling to a suitable substance, may germinate and give rise to a fresh mycelium. **Sexual Reproduction :** When the supply of nutritive material is poor, the plant reproduces itself sexually. At the time of sexual reproduction, the ends of two hyphæ become swollen and come in contact with each other; each swollen end of a hypha is a *gametangium* (Fig. 145). The contents of the swollen ends are then cut off by walls and unite into a single protoplasmic mass by the degeneration of the walls at the point of contact (Fig. 145). The structure thus formed is called a *zygospore* (Fig. 145 & 146. z) which, on germination, gives rise to a hypha which may at once develop a *sporangium* (Fig. 145) or the hypha may once branch before it does so but it never forms a network of mycelium like that produced from a *spore*.

**Torula form of Mucor :** If Mucor is grown in a sugary liquid, the hyphæ become divided up into a number of parts by walls. Each of these parts, on germination, may either produce a mycelium or like the yeast plant is capable of budding and producing alcoholic fermentation. This form of Mucor is known as the *Torula form*. Sometimes the separate cells are large and thick-walled, when they are known as *Chlamydospores*.

**Inter. Questions on "Mucor" from 1909-22.**

1. Describe any fungus known to you. (C. U. 1909).
2. Describe Mucor in detail. (C. U. 1910).
3. Give an account of the life-history, with special reference to the mode of reproduction, of any fungus you have examined. (C. U. 1918).

## Sub-Class : Oomycetes.

# Types: PHYTOPHTHORA & PYTHIUM.

**Habitat:** *Phytophthora infestans* is a parasitic fungus which causes the potato disease. **Microscopic Structure:** The hyphae (Fig. 147. b) of this fungus usually branch between the cells of the host plant, sending *haustoria* (Fig. 147. a) into their interior and thus absorbing their nutritive juices. **Asexual reproduction:** The mycelium of this fungus which is developed inside the tissues of the host, sends out hyphae through the *stomata of the leaves* and these hyphae bear *gonidangia* (Fig. 148. A) at their apices. In wet weather, each gonidangium gives rise to several *biciliate zoogonidia*. Each zoogonidium, on coming to rest, gives rise to a mycelium which penetrates the tissues of another leaf. The gonidangium may also germinate directly without undergoing division and forming zoogonidia. **Sexual Reproduction:** Sexual reproductive organs have not as yet been observed in *Phytophthora infestans*. The sexual reproduction of this group is best seen in a species known as the **Pythium de Baryanum.** This fungus is the cause of the disease known as the "damping off" of Cress seedlings. It begins its growth as a parasite and

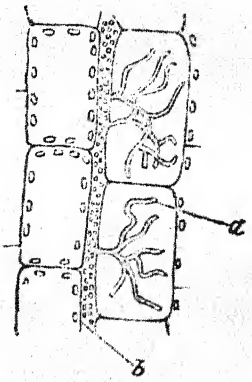


Fig. 147. *Phytophthora.*
Four cells of potato plant infested with *Phytophthora. Hypha* (b) running between the cells and sending *haustoria* (a) into the interior.

subsequently lives as a saprophyte on the dead seedlings. The fungus makes its way *through the cells* (Fig. 149. pa) of the host plant by means of the ferments which it excretes. *Asexual reproduction* of this species agrees mainly with that of *Phytophthora*. **Sexual Reproduction:** When its food supply is running short and conditions are generally not favourable to development, *Pythium* resorts to sexual reproduction. The *female* sexual organ, called the **oogonium**, is formed in this way—Terminal (Fig. 149A. to) or intercalary (Fig. 149A. io) swellings arise on some of the hyphae. Each of these swellings becomes cut off by a wall and from a part of its protoplasm, the *female cell* called the *oosphere* (Fig. 149 A & B. os) is formed, while the remaining portion of the contents of oogonium forms a peripheral layer known as the *periplasm* (Fig. 149 A & B. pp). Though the oogonium contains a large number of nuclei, only *one* of these is retained in the oosphere, the rest remaining in the periplasm. Generally on the same hypha, just below the oogonium, the *male* sexual organ, called the *pollinodium* (Fig. 149 A & B. a), arises. It is a much thinner branch than that which forms the oogonium, and, like it, is cut off by a transverse wall. It grows toward the oogonium until it comes in contact with its wall. Its contents become differentiated into a central portion, which is the *male gamete*, and *periplasm*. A short tube is put

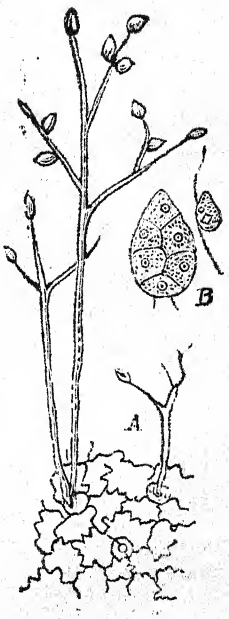


Fig. 148. *Phytophthora*

A—The gonidangia formed on long filaments which grow out from the interior of the potato leaf through the stomata; B—The development of *zoogonidia* in a gonidangium; a single zoogonidium is shown at the right.

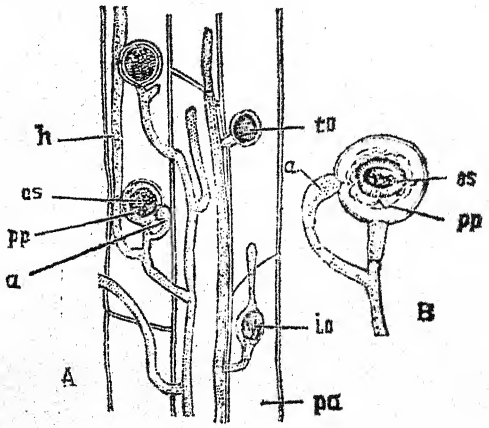


Fig. 149. *Pythium.*

A—Longitudinal section of a Cress seedling attacked by Pythium ; *hypha* (h) of the fungus developed inside the *parenchymatous cells* (pa) of the seedling ; *female* sexual organ, *oogonium*, containing female cell, *oosphere* (os), and *periplasm* (pp) ; *male* sexual organ, *pollinodium* (a) ; *terminal* (to) development of the oogonium ; *intercalary* (io) development of the oogonium.

B—Magnified view of the *oogonium* containing *oosphere* (os) and *periplasm* (pp) ; *pollinodium* (a).

out by it, which pierces the wall of the oogonium and makes its way down to the oosphere. The tip of this short tube then opens, and the male gamete of the pollinodium passes down the tube and unites with the oosphere. The oospore produced as the result of this fertilisation, forms a thick wall, the outer layers of which appear to be the remains of the periplasm. The oospore, on germination, may give rise to a new mycelium or its contents divide up into a number of zoospores, each of which reproduces the plant ; or again, the contents of the oospore may pass into a delicate thin-walled swelling and then divide up to form zoospores.

——:o:——

# Type : EUROTIUM.

**Habitat :** *Eurotium Aspergillus glaucus* grows on bread, jam, old boots and on such other substances. It is a white saprophyte, becoming green after the appearance of the reproductive structures. **Microscopic structure :** The body of the plant is coenocytic and consists of a much branched mycelium the hyphae of which are divided at intervals by transverse walls (Fig. 150). The mycelium contains granular protoplasm, vacuoles, oil-globules and several nuclei.

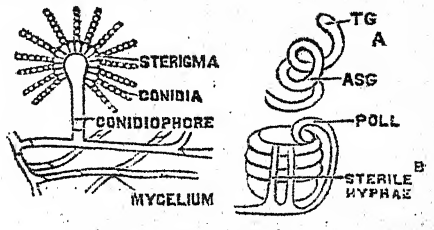


Fig. 150. *Eurotium.*
TG—*Trichogyne* : ASG—*Ascogonium* ; POLL—*Pollinodium.*

**Asexual Reproduction :** Numerous branches from the hyphæ shoot up in the air and the contents of each are separated from those of the mycelium by a wall. The tip of each branch swells and develops small elongated structures called the *sterigmata* (Fig. 150). The stalk on which the sterigmata are situated is called the *conidiophore* (Fig. 150). From the apex of each sterigma, a chain of *conidia* is formed by abstriction. Each conidium consists of a green wall, a mass of protoplasm, oil-globules and many nuclei. The conidia are light and are easily borne in the air, and, falling to a suitable organic substance, each of them immediately germinates and produces a mycelium. **Sexual Reproduction :** Certain thin branches of the mycelium become coiled and each forms a multinucleate structure called the *archicarp* (female organ), the terminal portion of which is called the *trichogyne* (Fig. 150. TG), the part below, the *ascogonium* (Fig. 150. ASG), and the remaining portion forming the *stalk*. At a later stage,

another branch called the *pollinodium* (male organ, Fig. 150. POLL) grows up by the side of the archicarp and the tip of this branch applies itself closely to the trichogyne. Fertilisation is effected by the contents of the pollinodium passing into the trichogyne. Branches (Fig. 150. STERILE HYPHAE) then grow up from the stalk of the fertilised archicarp and completely enclose it forming an investment known as the *perithecium*. Meanwhile, the fertilised archicarp becomes divided up by a number of transverse walls and from each of these cells, multicellular branches called the *ascogenous branches* are produced, which penetrate into the cells of the investment The end of each ascogenous branch is cut off by a wall and forms unicellular sporangium called the *ascus*. Each ascus is at first binucleate, these two nuclei then unite into one which repeatedly divides till eight nuclei are formed. From these eight nuclei, *eight* spores called the *ascospores* are formed by free-cell-formation. The contents of the perithecium gradually degenerate and supply the asci with food materials. The ascospores, when ripe, are set free by the bursting of the wall of the perithecium and each of them immediately or after a period of rest may give rise to the mycelium of the plant.

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## Type : **PENICILLIUM.**

Habitat : *Penicillium glaucum* is a saprophytic fungus which lives on almost all organic substances. Micros-

copic Structure: The body of the plant is coenocytic and consists of a much branched mycelium the hyphae of which are divided at intervals by transverse walls. The mycelium contains granular protoplasm, vacuoles, oil-globules and several nuclei. Asexual Reproduction: In the absence of air and light, erect branches rise from the mycelium and long chains of asexual reproductive structures known as *conidia*, are produced at the apex of each of these branches known as *conidiophores* (Fig. 151). The conidia are scattered through the air and on germination, each of them produces the mycelium of the plant. Sexual Reproduction: Sexual reproduction takes place very rarely in Penicillium. The sexual organs of *Penicillium* agree in essential points with those of *Eurotium*. Certain thin branches of the mycelium become coiled and each forms a multinucleate structure called the *archicarp* (female organ), the terminal portion of which is called the *trichogyne*, the part below, the *ascogonium*, and the remaining portion forming the *stalk*. At a later stage, another branch called the *pollinodium* (male organ) grows up by the side of the archicarp and the tip of this branch applies itself closely to the trichogyne. Fertilisation is effected by the contents of the pollinodium passing into the trichogyne. Branches then grow up from the stalk of the fertilised archicarp and completely enclose it forming an investment known as the *perithecium*. Meanwhile the fertilised archicarp becomes divided up by a number of transverse walls and from each of these cells, multicellular

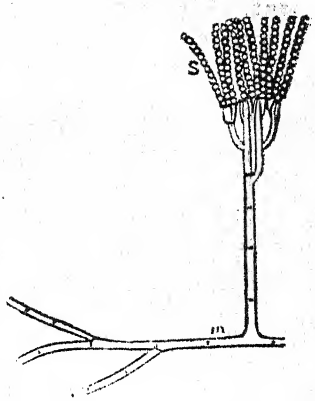


Fig. 151. *Penicillium*.
M—*Mycelium;* S—Chains of *conidia*.

branches called the *ascogenous branches* are produced, which penetrate into the cells of the investment. The end of each ascogenous branch is cut off by a wall and forms unicellular sporangium called the *ascus*. Each ascus is at first binucleate, these two nuclei then unite into one which repeatedly divides till *eight* nuclei are formed. From these eight nuclei, *eight* spores called the *ascospores* are formed by free-cell-formation. The contents of the perithecium gradually degenerate and supply the asci with food materials. The ascospores, when ripe, are set free by the bursting of the wall of the perithecium and each of them immediately or after a period of rest may give rise to the mycelium of the plant.

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## Type: CLAVICEPS.

**Habitat:** *Claviceps purpurea* (Ergot) is parasitic in the young ovaries of different members of the Gramineae, particularly of *Rye*. **Microscopic structure:** The ovaries of the flowers of such plants are infected in *early summer* by the spores of this fungus known as the *ascospores*. Each spore germinates and gives rise to a mycelium. **Asexual Reproduction:** Erect branches, known as the *gonidiophores*, are developed from the mycelium and at the top of each gonidiophore, an asexual reproductive structure, known as the *gonidium*


Fig. 152. *Claviceps.* Young *sclerotium* (c) growing up and supplanting the old *sphacelia* (Sph).

is formed. At the same time a sweet fluid is given out. This so-called **Honey-dew** is eagerly sought by insects and the gonidia embedded in it are carried to the ovaries of other plants. The gonidial form of this fungus is known as the **Sphacelia** (Fig. 152 & 153). Later in the year the mycelium, after absorbing the tissue of the ovary forms in the place of the ovary a hard structure known as the **sclerotium** (Fig. 152. c). The sclerotium copiously

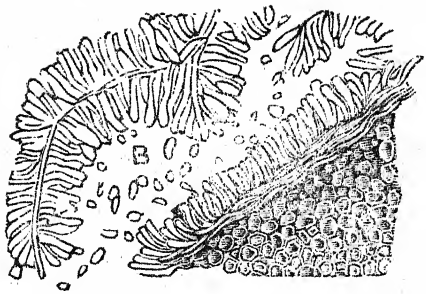


Fig. 153. *Claviceps.*

Section through the *junction of the Sphacelia* with the sclerotium, showing the gonidia which are scattered among (B).

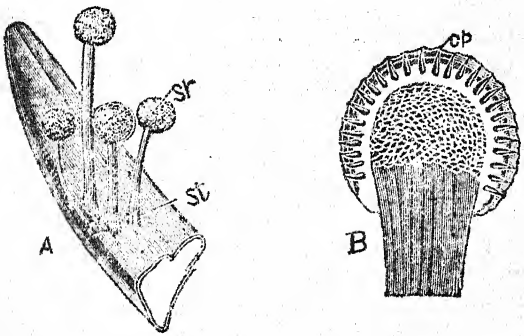


Fig. 154. *Claviceps.*

A—Portion of the *Sclerotium* (St) with *four Stromata* (Sr).

B—Section through a *stroma* showing *perithecia with openings, ostioles,* (cp).

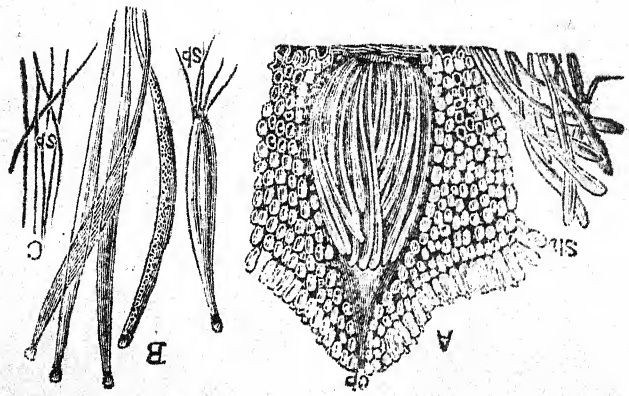


Fig. 155. *Claviceps.*

A—Magnified view of a section through a *perithecium* with the *ostiole* (cp) and contained *asci*; *Asci* (sh) separated from within the perithecium.

B—Magnified view of some *asci* from one of which the *ascospores* (sp) are coming out.

C—Magnified view of *ascospores* (sp).

supplied with food material (fat), eventually falls to the ground, where it passes the *winter* and germinates in the following *spring* when the Rye is again in flower. Each sclerotium, on germination, produces a number of structures known as the *stromata* (Fig. 154. A). Each stroma (Fig. 154. B) consists of a stalked globular head on the surface of which are situated the openings or *ostioles* (Fig. 154 cp & 155A. cp) of numerous flask-shaped cavities called the *perithecia*. Within each perithecium, a large number of sporangia known as the *asci* are developed (Fig. 155 A & sp) and each ascus produces *eight* thread-like spores known as *ascospores* (Fig. 155. B. & C. sp) which are ejected and carried by the wind to the flowers of the Grass.

## Type : **YEAST** * (C.U. 1914, 1916, 1920).

Habitat : The *yeast* plant is a saprophytic fungus which, when developed in a sugar solution, is capable of converting sugar into *alcohol* and *carbon dioxide gas*. Microscopic structure : Each plant consists of a *wall* enclosing a *mass of protoplasm* in which occur a well-marked *vacuole*, a number of *oil-globules* and a structure resembling *nucleus*.

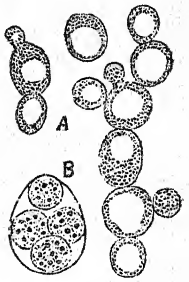


Fig. 156. *Yeast.*
A—Several *Yeast plants* some of which have produced *buds*.
B—Yeast plant which has developed *four ascospores*.

Reproduction : Reproduction takes place in the presence of a fairly high temperature and nutrient solution. Each plant reproduces itself by producing a bud which lives as an independent plant after being detached from the parent plant ; this mode of reproduction is known as *budding, gemmation* or *pullulation* (Fig. 156. A). Sometimes a chain of buds is at first produced by the repeated division of cells but subsequently the buds become isolated from one another.

Uncommon forms of reproduction.

If the supply of food materials is insufficient or if other conditions of living are unfavourable, the Yeast plant usually divides into *four* (sometimes *eight or less than four*) parts and thus four bodies called *ascospores* (Fig. 156. B) are formed. The ascospores are set free by the bursting of the wall of the parent cell and when favourable conditions of existence return, each of them reproduces itself by budding.

A form of *sexual reproduction* has been observed in one species of Yeast. Two cells lying close to each other put out short beak-like processes which ultimately unite with each other. The contents of these processes then unite and thus apparently true *conjugation* takes place, the nuclei uniting together. The

product of conjugation is the *zygospore* which, after a period of rest, germinates and gives rise to *spores* in its interior.

### Inter. Questions on "Yeast" from 1909—22.

1. What is Yeast? Describe its structure, life-history and mode of multiplication. (C. U. 1914, 1920).

2. How does the Yeast plant differ from a higher plant as regards its structure, general mode of life and reproduction? (C. U. 1916).

*Ans.* Higher plants are multicellular, Yeast is unicellular. Higher plants normally reproduce themselves asexually, sexually and sometimes vegetatively but the normal mode of reproduction of the Yeast plant is vegetative; in exceptional cases, the Yeast plant reproduces itself asexually or sexually. Higher plants generally live by building up complex substances from simpler ones through the action of chloroplastids in light, but the Yeast plant is a fungus which sets up alcoholic fermentation and obtains nourishment by this process.

## Class: Aecidiomycetes.

## Type: PUCCINIA.

**Habitat:** *Puccinia graminis* is a parasitic fungus which is also known as the "Rust of Wheat." It inhabits two host plants (e. g. Grass & Barberry)

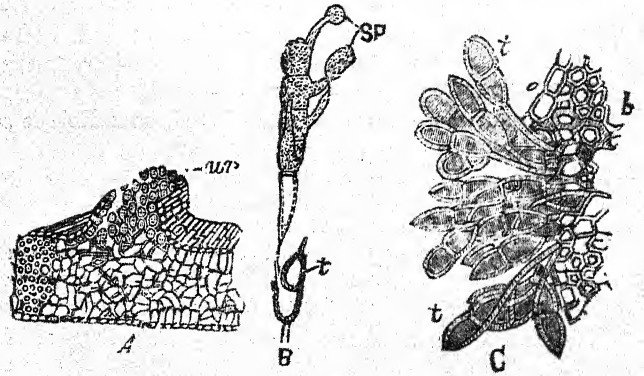


Fig 157. *Puccinia.*

A – Section of Grass leaf infested with *Puccinia graminis* showing the *uredospores* (ur) bursting through the epidermis of the leaf.

B—*Teleutospore* (t) germinating and producing a *promycelium* with *sporidia* (Sp).

C—Section of a straw showing the *epidermis* (o), parenchymatous cells (*b*) beneath the epidermis, *teleutospores* (t) bursting through the epidermis.

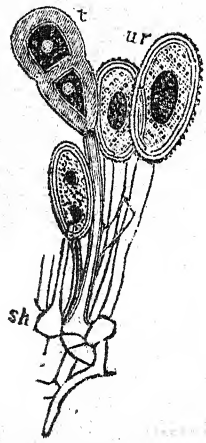


Fig. 158.

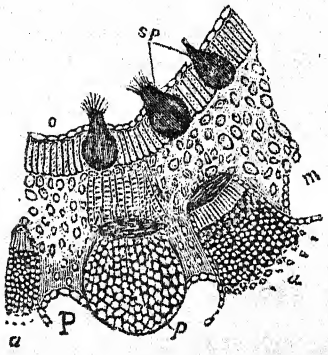


Fig. 159.

Fig. 158—Group of three *uredospores* and one *teleutospore* (t) springing from the *mycelium* (sh).

Fig. 159—Section through a leaf of the Barberry infested with Puccinia, showing the *epidermis* (o) of the upper surface of leaf and *spermogonia* (Sp). Lower surface of leaf contains a layer of cells constituting the *peridium* (P) surrounding *accidium* (a) bearing *accidiospores*.

in the different stages of its existence. **Microscopic structure :** During the summer, spores, known as the *aecidiospores*, germinate on the surface of the stem and leaf of Wheat and other Grasses and produce an incompletely septate mycelium which penetrates through the passage of the stomata and sends *haustoria* into the parenchymatous cells of the plant. Each aecidiospore has *two* nuclei. The mycelium developed from the germination of an aecidiospore produces patches of gonidia known as the **uredogonidia** or **uredospores** (Fig. 157A. ur), each borne upon

a short stalk and containing *two* nuclei. The uredospores develop beneath the epidermis of the host plant, and being of a *yellow* or *reddish* colour, give the part a *rusty* appearance; hence this fungus is known as the "Rust of Wheat." The uredospores are scattered on the rupture of the epidermis and germinate in a few hours on the surface of other grass plants, and on these plants only they develop new mycelia, which again produce masses of uredospores in from six to ten days. While the fungus in its "uredo-form" thus produces many generations of plants in a *summer* on the grass plants, the formation of a new form of gonidium (**teleutogonidium** or **teleutospore**, Fig. 157 C.t) commences towards the *end of the summer* in the older clusters of uredospores (Fig. 158.t). Generally, the teleutospores occur *two* together upon a single stalk developed by the side of the roundish unicellular uredospores (Fig. 158 .t). Soon the formation of uredospores ceases altogether and the teleutospores only are henceforth produced. The teleutospores remain in a resting state on the grass-stems *during the winter* and *germinate in the spring*. On germination, one or both of teleutospores produces a small structure known as the *promycelium* (Fig. 157.B) which is usually of *four* cells. Each cell puts out a small stalk (*gonidiophore*) from which a small gonidium, called a *sporidium* (Fig. 157 B.sp), is produced. Each sporidium is a very small thin-walled structure which is easily carried by the wind. *It is incapable of developing a mycelium upon the* Grass *but if it falls upon a leaf of the* Barberry, *it germinates, sending a hypha through the epidermis, instead of penetrating a stoma like the uredogonidium.* The mycelium developed from this hypha forms a dense network in the intercellular spaces of the leaf. On the upper and lower surface of a leaf of the Barberry, yellowish swollen spots are found *in the spring*. The swollen spots on the *upper surface* of the leaf contain *spermogonia* (Fig. 159. sp) which make their

appearance somewhat *earlier* than the *aecidia* (Fig. 159.a) occurring in the swollen spots on the *lower surface* of the leaf. The *spermogonium* (Fig. 159. sp) is a flask-shaped structure. Hair-like filaments line the cavity of the spermogonium and bursting through the epidermis of the leaf, project like a brush beyond the mouth of the spermogonium. The bottom of the spermogonium is covered with short hyphae, at the extremities of which a number of spore-like bodies are formed; these spore-like bodies are known as the *spermatia*. The part played by the spermatia in the further development of the Fungus is not known. The spermatia may be regarded as functionless male cells. At a *later period*, the *aecidia* (Fig. 159.a) make their appearance, usually on the underside of the leaves. They lie at first beneath the epidermis of the leaf, forming tuber-like bodies enclosed in an envelope of delicate hyphae. In the mature state, the aecidium ruptures the epidermis of the leaf and forms an open cup, the wall (*peridium* Fig. 159.P) of which is produced from the hyphal branches at the bottom of the cup from which numerous closely associated chains of spores (*aecidiospores*) are formed. Each aecidiospore possesses *two* nuclei. The aecidiospores, thus produced on the leaves of the Barberry, develop a mycelium only when they germinate on the surface of the leaf or stem of a grass plant like Wheat.

—o—

## Class : Basidiomycetes.

## Type : AGARICUS.

**Habitat :** The plant, which is popularly known as the *Mushroom*, is a saprophytic fungus which grows on meadow, damp-wood and such other places and substances.

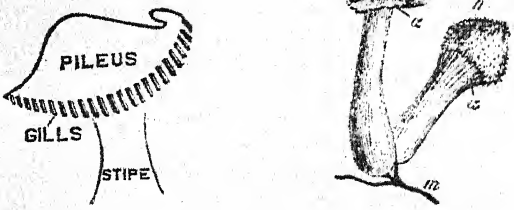


Fig. 160. *Fructification of Mushroom.*

*Left Fig.* Shows *Pileus*, *Gills* and *Stipe*.

*Right Fig.* Shows *Mycelium* (m); *Annulus* (a) is the remaining portion of the ruptured *velum* a portion of which is attached; *Gills* or *Lamellae* (l); *Pileus* (*h*).

**Microscopic Structure :** The body (*mycelium*, Right Fig. 160.m) of the plant lies almost totally embedded in the substratum and is composed of a much-branched tube-like structure which is divided into many parts by walls. Each of these parts contains *protoplasm*, *many nuclei*, *vacuole* and *oil globules*

**Asexual reproduction :** The part of the plant which is seen above ground is the *asexual reproductive structure* which consists of a stalk, known as the

*stipe* (Left Fig. 160), bearing at its apex a large circular, somewhat umbrella-shaped expansion known as the *pileus* (Fig. 160 Left, and Right. h). On the underside of the pileus, there are a number of plates of tissue known as the *gills* (Right Fig. 160. l) or *lamellae* most of which radiate from the stipe to the edge of the pileus. Towards the upper end of the stipe, there is a ring of tissue known as the *annulus* (Right Fig. 160.a) which is the remaining portion of a membrane known as the *velum*. At one time, the velum extended from the stipe to the margin of the pileus and thus protected the gills or lamellae. A transverse section of a gill shows that it consists of a central mass of interwoven hyphae known as the *trama* (Fig. 161 B.f). As the hyphae approach the surface of the lamella, the cells become shorter. The terminal cells of the hyphae constitute the *hymenial layer* or *hymenium* (Fig. 161 C.h) which consists of somewhat elongated club-shaped cells, some of which bear spores and are termed *basidia*, whilst others are sterile and are

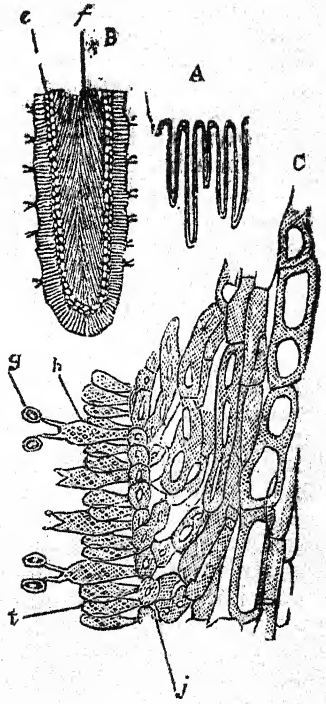


Fig. 161. *Section through a Gill of Mushroom.*
A—Section of the *pileus* showing *lamellae*. B—Section of a lamella more highly magnified showing *trama* (f) and *hymenium* (e). C—A *portion of the lamella* more highly magnified showing *sub-hymenial layer* (j), *paraphysis* (t), *basidium* (h), and *basidiospore* (g).

termed *paraphyses* (Fig. 161 C. t). Each basidium develops at its apex 2 to 4 rod-like structures, the *sterigmata*, and at the apex of each sterigma a single *spore* (Fig. 161 C.g) is formed. These spores are termed *basidiospores*. Beneath the hymenial layer, there is a layer of very short cells ; this layer is known as the *sub-hymenial layer* (Fig. 161 C.j). Each basidiospore possesses *two nuclei* and each, on being detached from the sterigma, germinates and develops the mycelium of a new Agaricus campestris (Mushroom).

—o—

## Sub-division : LICHENS.

General description and Microscopic structure : A *lichen* is not a single plant, but is made up of two plants, an Alga and a Fungus, growing together for mutual advantage. The lichens furnish a most interesting example of *symbiosis* (*syn*, together ; *bio*, life). The Alga and the Fungus co-operate, with the result that the two-fold organism can often live in situations uninhabited by either alone or by any other form of vegetation. The Fungus derives its nourishment saprophytically from the organic matter produced by the assimilation of the Alga through its green colouring matter ; it can also send haustoria into the Algal cells and so exhaust their contents. The Alga receives from the Fungus inorganic substances also. The Alga may be unicellular or filamentous and may belong either to the *Cyanophyceae* or to the *Chlorophyceae* ; the Fungus belongs chiefly to the *Ascomycetes*, more rarely to the *Basidiomycetes*. The Alga and the Fungus of a Lichen can be cultivated separately, similarly, if the spores of the Fungus be sown among the Alga, the lichen may be produced. Many lichens, on drying up, become rather brittle without permanent injury ; on being moistened, they become soft and leathery. Thus they can survive in a very dry situation. The Algal cells or filament may be distributed throughout

the body of the lichen, when the lichen is said to be *homoiomerous* ; or the Algal cells may be arranged in a definite layer near the surface of the body of the lichen, when it is said to be *heteromerous*. It may be generally stated that the form of the body of the lichen is determined in the homoiomerous Lichens by the Alga, in the heteromerous Lichens by the Fungus. In the latter case, *three* main forms are distinguished—*foliaceous, fruticose* and *crustaceous*. The Foliaceous Lichens (Fig. 164) generally cover branches and tree-trunks in a moist atmosphere with grey shaggy tufts. The Fruticose Lichens (Fig. 162) form the picturesque yellow patches on old walls, tiles etc. ; in this type, the body of the Lichen adheres to the substratum through the greater part of its length. The Crustaceous Lichens (Fig. 163) often form various markings on old wood and the fructifications of which alone stand out from the substratum. A section of the body of one of the foliaceous lichens shows the following structures from the upper to the lower surface (Fig. 165)—(1) Upper *cortical layer* (o) ; (2) *Layer of algae* (*g*) which are symbiotic with the fungus; (3) *Medullary layer* (m consisting of a dense strand of hyphae running longitudinally ; (4) Lower *cortical layer* (u) from which are developed root-like structures called *rhizines* (r) consisting of strands of interwoven hyphae.

Reproduction : The reproductive organs of lichens are always produced by the *fungal constituent*. In a few cases only, sexual reproduction takes place. The female organ, the *carpogonium*, is a multicellular filament of which the lower part is coiled (cf. *Eurotium* p. 347), and the upper part projects above the surface of the body of the lichen as the *trichogyne*. The male cells (*spermatia*) are developed in cavities (*spermogonia*) on the body of the lichen. The spermatia are abstricted from hairs which line the spermogonium. The spermatia are very small and so, though *non-motile*, they get carried by water to the trichogyne. They become attached to the tip of the

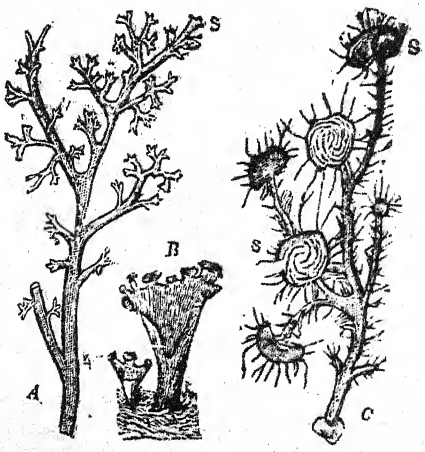


Fig. 162. *Fruticose Lichens.*
Fig. 162 *Fruticose Lichens* (A,B & C) with *apothecia* (S).

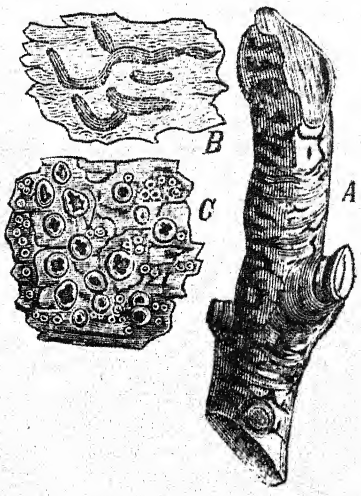


Fig. 163. *Crustaceous Lichens.*
Fig. 163. *Crustaceous Lichens* (A, B & C).


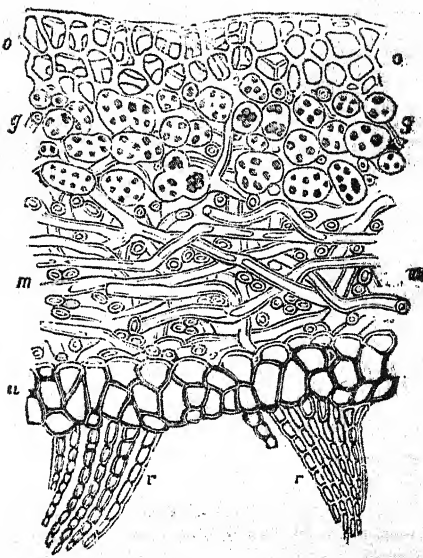


Fig. 164. *Foliaceous Lichen.* Fig. 165. *Section of a Foliaceous Lichen.*

Fig. 164. *Foliaceous Lichen* bearing *apothecia* (s).

Fig. 165. Transverse section of a *Foliaceous Lichen* showing *cortex* of the upper surface (o) ; *algal cells* (g) ; the hyphae of the fungus forming the *medullary layer* (m) ; *cortex* of the under surface (u) ; root-like outgrowths, *rhizines* (r), of the under surface.

trichogyne and the contents of the spermatium pass into the trichogyne and fertilise the carpogonium. The result of this fertilisation is the formation of a very complicated fructification known as an *apothecium* (Fig. 164. s). This consists of a flat cup containing (1) *asci* (Fig. 166. As) formed at the ends of branches which grow out of the coiled part of the fertilised carpogonium, and (2) sterile cells (*paraphyses*, Fig. 166.P) arising from the branches which spring from below the coil. Generally *eight ascospores* are developed within each club-shaped ascus. When the ascospores are ripe, the para-

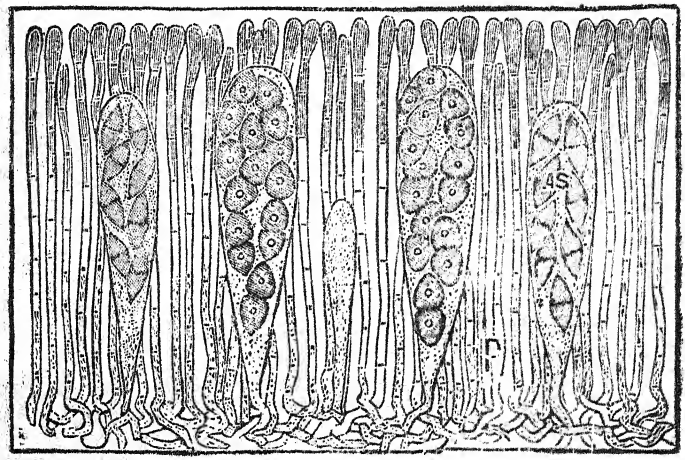


Fig. 166. *Ascus of a Foliaceous Lichen.*
Fig. 166. Shows some *asci* (As) and *paraphyses* (P) between the asci.

physes swell and the ascospores are shot out with considerable force. It seems probable that some of the Algal elements usually work their way to the surface and are set free from the Lichen with the ascospores. On germination, the ascospore produces hyphal filaments, which invest the Algal cells, and the two organisms continue their growth together as a lichen. (In some lichens, the carpogonium is much reduced, the trichogyne is wanting and the reproduction is *apogamous*, that is, the apothecium containing the asci is directly produced from the *unfertilised* female mass of protoplasm of the carpogonium. It has also been shown, in some cases, that the spermatia of Lichens can directly germinate and produce a mycelium). Asexual reproduction: Since the Fungus of the Lichen belongs chiefly to the *Ascomycetes* and more rarely to the *Basidiomycetes*, the *asexual reproduction* of a Lichen agrees with that of a

member of the Ascomycetes e. g. *Eurotium* (See p. 347) or with a member of the Basidiomycetes e.g. *Agaricus* (See p. 358). Vegetative reproduction : Some Lichens reproduce themselves also *vegetatively* by structures known as the *soredia* which consist of one or more Algal cells invested by the hyphae of the Fungus. The soredia are set free from the parent plant and grow into new Lichen plants.

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## Division : BRYOPHYTA.

### Class : Haepaticeae or Liverworts.

### Type : MARCHANTIA.

### Description of the gametophyte.

Habitat : *Marchantia polymorpha* is commonly found in moist and shady places. Morphological & Microscopic structure : The body of the plant is a flat dorsiventral green thallus which is dichotomously branched and the margin of which is wavy (Fig. 167 B.). On the underside of the thallus and especially on its midrib (Fig. 167B. v), there are numerous unicellular root-like structures called *rhizoids* and multicellular scales called *ventral scales*. The *growth* of the thallus takes place by a *group of cells at each growing-point* (Fig. 167 B.a).

On cutting a transverse section through the midrib of a *thallus*, the following structures can be successively seen from the upper to the lower surface :—(1) *The superficial layer* (Fig. 169 B. E) containing a large number of openings called *pores* (Fig. 169 B. S) ; the cells bounding each pore contain but little chlorophyll while chlorophyll is abundant in the rest of the surface. Each pore leads down into an (2 *air-chamber* (Fig. 169 B. AC) bounded at the ends by cells connecting the superficial layer with the rest of the thallus. On the floor of each

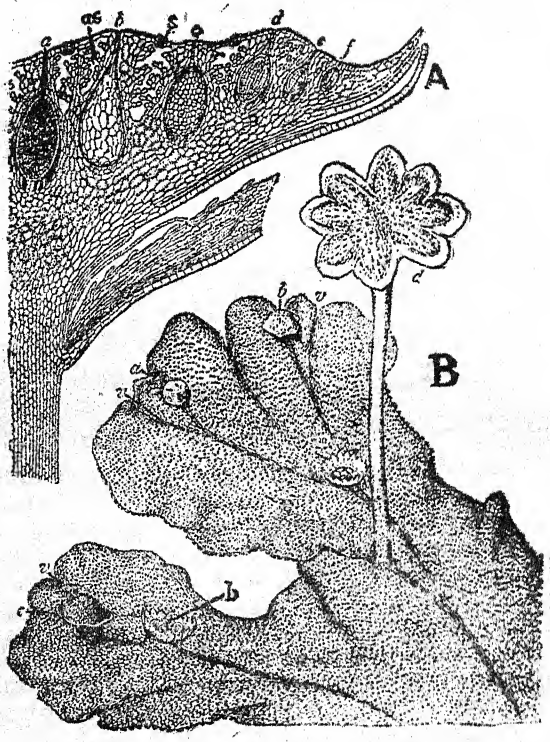



Fig. 167. *Thallus & Male reproductive structure of Marchantia.*
Fig. 167. A—*Assimilating tissue* (as) ; *stoma* (s) ; *antheridia* (f, e, d, b) in various stages of development ; *mature antheridium* (a) and *ostiole* (o) of the antheridium. B—*Thallus* of Marchantia with *gemmae cups* (b), *vein* (v), *growing-point* (a) and *antheridiophore* bearing a *receptacle* (d) containing antheridia.

air-chamber there are peculiar (3) ***branched hairs*** (Fig. 169 B. AT) with abundant chlorophyll and constituting the most important assimilating portion of the plant. Below the assimilating tissue, there are several layers of (4) ***parenchymatous cells***, some of which contain starch-grains, whereas others contain

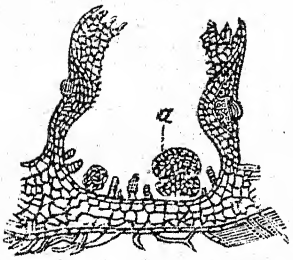



Fig. 168. *Section of bud of Marchantia.*

Fig. 168—Thallus of Marchantia with *gemmae* (a).

a peculiar oily substance (Fig. 169 B. O). Below the parenchymatous cells, there is the (5) *lower limiting layer* to which are attached *unicellular rhizoids* (Fig. 169 B. R, and *multicellular scales* (Fig. 169 B. SC).

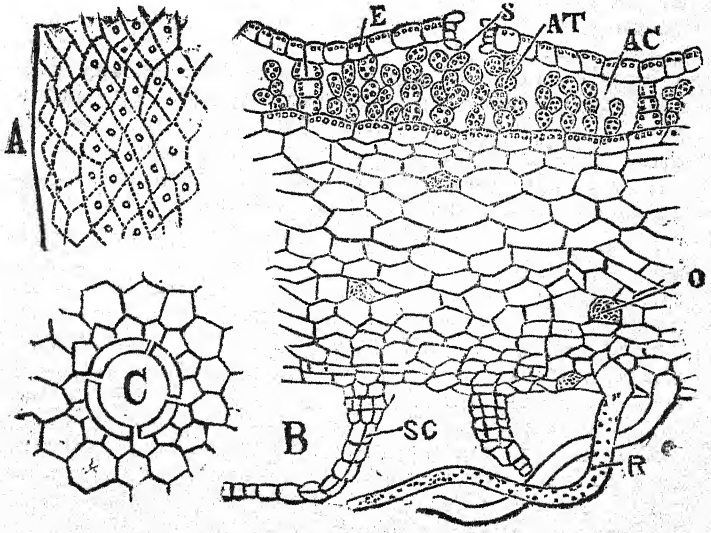



Fig. 169. *Section of thallus of Marchantia.*

A—*Surface of the thallus*, the diamond shaped areas marking *air-chamber.*

B—A section through the *middle region of the thallus* showing the *superficial layer* (E) containing the *pore* (S); *air-chamber* (AC) containing the *assimilating tissue* (AT); *parenchymatous cells* containing *oily substance* (o); *unicellular rhizoid* (R) and *multicellular scale* (SC) developed from the lower *limiting layer*.

C—Surface view of the *pore* which opens into an air-chamber.

**Vegetative Reproduction.**

Little cups, called *cupules* (Fig. 167 B.b & Fig. 168.a), occur on the upper surface of the thallus. The cupules have membraneous margins and within them green buds called *gemmae* are developed. Each bud, when set free from the parent plant, grows up into a new plant.

**Sexual Reproduction.**

At certain seasons of the year, special branches grow up into the air. In some plants, these branches bear flattened heads while in other plants the heads of such branches are star-shaped. The branches bearing flattened heads are known as the *antheridiophores* (Fig. 167B. d) while the flattened heads themselves are receptacles bearing the *antheridia* (Fig. 167 A. a) or male reproductive organs. The branches bearing star-shaped heads are known as the *archegoniophores* (Fig. 170) and the star-shaped heads themselves are receptacles bearing *archegonia* (Fig. 171 A. a) or female reproductive organs.

A longitudinal section through the *receptacle on an antheridiophore* shows that it contains (1) *Rhizoids* and *Scales* on the lower surface (Fig. 167. A); (2) *air-cavities* opening on the upper surface by means of structures called *pores* (Fig. 167 A. S); (3) Flask-shaped cavities containing *antheridia* (male organs) opening *on the upper surface* by means of structures called *ostioles* (Fig. 167 A. o). Each *antheridium* (Fig. 167 A. a) consists of a stalk bearing an oval structure which contains numerous *spermatocytes* (spermatozoid-mother-cells). Each spermatocyte liberates a *biciliate spermatozoid* (*male cell*).

A longitudinal section through the *receptacle on an archegoniophore* shows that it contains (1) Large

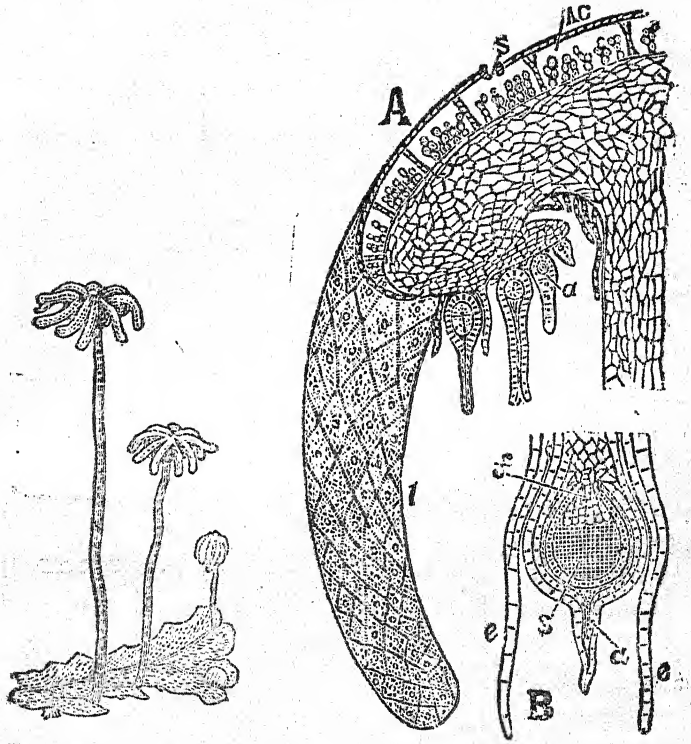



Fig. 170. *Female plant of Marchantia bearing archegoniophores.*

Fig. 171. *Archegonia & Capsule of Marchantia.*

Fig. 170—*Female plant* of Marchantia showing umbrella-like *archegoniophores with receptacles* in various stages of development.

Fig 171—A—Portion of a lengthwise section of a *young finger-shaped receptacle* showing a row of *archegonia* (a) hanging down from the lower surface; *air-chambers* (AC) are present on the upper surface with *pores* (s); (f) is one of the finger-like lobes with diamond-shaped areas indicating air-chambers. B—A *young sporophyte* (s) within the *archegonium* (a); the region which is to become the *spore-case* is indicated by the cross lines, and the small *foot* is attached to the base of the archegonium and is indicated by the white portion (f); *perigynium* (e) is developed around the archegonium.

*mucilage-cells* in the tissue of its body ; (2) *Air-cavities* opening on the *upper surface* by means of structures called *pores* (Fig. 171 A. S) ; 3) On the *under surface*, there are the *archegonia* (Fig. 171 A.a) or female organs covered by a curtain-like membrane called *perichaetium* (Fig. 172 A & B. f). Each archegonium (Fig. 171 A. a) is a pitcher-shaped structure situated upon a short stalk. The pitcher-shaped structure is composed of a *long neck* and a *swollen venter*. The neck has a central cavity which contains a row of cells called *neck-canal-cells*. A large cell, called *oosphere* (female gamete), lies within the cavity of the venter and the passage between the cavity of the neck and that of the venter is guarded by a cell called *ventral-canal-cell*.

**Fertilisation :** When the archegonium attains maturity, the ventral-canal-cell and the neck-canal-

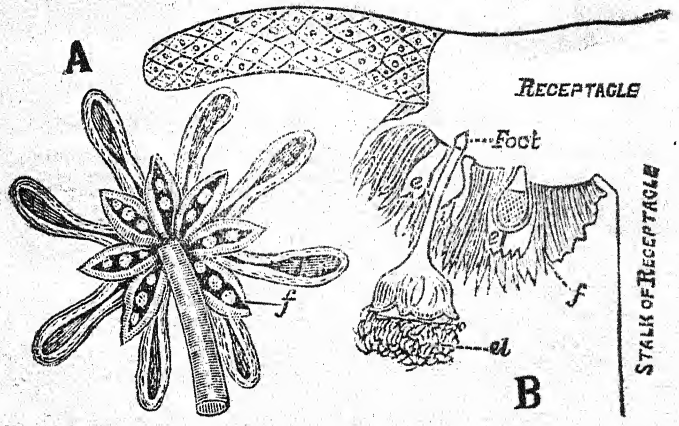



Fig. 172. *Sporophyte of Marchantia.*

A—Lower view of an *old female receptacle*, showing the *sporophyte* in rows between the *perichaetium* (f) like peas in a pod. B—Section of a *receptacle* showing a *mature sporophyte* anchored by its *foot* and projecting beyond the *perichaetium* (f) ; the *spore-case* is open, exposing the mass of *elaters* (el) ; a *young sporophyte* is shown at the right still enclosed within the wall (*calyptra*) of the archegonium ; special envelopes, *perigynia* (e), around the archegonia and sporophytes.

cells break down into a mucilaginous substance which forces open the lid-cells. The mucilaginous substance contains a *protein*, the smell of which attracts the spermatozoids. One spermatozoid enters into the venter and after withdrawing the cilia unites with the oosphere forming a structure known as *oospore* which soon covers itself with a wall.

## Development and description of the Sporophyte.

After the formation of oospore, a structure called *foot* (Fig. 172. B & Fig. 173. A) is formed at the base of the archegonium and is inserted into the receptacle of the mother-plant which gives nourishment to the embryo through this structure. The oospore repeatedly divides and the structure thus formed is known as *sporogonium* (Fig. 171 B. S) which remains enclosed within the wall (*calyptra*) of the venter of the archegonium. A membrane, the *perigynium* (Fig. 171 B. e & Fig. 173. e), grows up from the base of each archegonium. The sporogonium then differentiates itself into a *stalk* (Fig. 172 B & Fig. 173.A) and a swollen structure called the *capsule* (Fig. 173.S). The capsule consists of a *wall* enclosing a structure known as the *archesporium* which gives rise to the *spores* and some spirally marked filaments known as the *elaters* (Fig. 173 A.L & Fig. 173 B). The elaters are stiff, elastic and hygroscopic and help to distribute the spores. When the spores

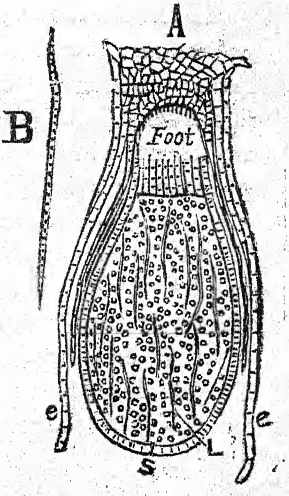



Fig. 173. *Capsule of Marchantia*,

A—Longitudinal section of the *sporophyte* showing *capsule* (s)

are mature, the capsule is forced out of the calyptra by the elongation of the stalk (Fig. 172 B) and the spores are liberated by the rupture of its wall.

and *foot* attached to the base of the archegonium ; *elaters* (L) and *perigynium* (e). B—Magnified view of an *elater*.

## Development of the Gametophyte.

Each spore, on reaching the ground, germinates at once and gives rise to a small germ-tube from which the Marchantia plant is subsequently developed.

## "Alternation of Generations" in the Liverworts.

In the life history of a Liverwort e. g. *Marchantia polymorpha*, we notice two stages or generations—*sexual* and *asexual*. The more conspicuous generation is the sexual or gametophyte (meaning *gamete*—bearing plant) which is represented by the thallus. The gametophyte is followed by the asexual generation or sporophyte (meaning *spore*-bearing plant) which is represented by the *sporogonium* and which is parasitic on the gametophyte. The occurrence of the gametophyte and sporophyte, one after another, in a life history constitutes an "alternation of generations". The life history of Marchantia polymorpha may be expressed by the following formula—

Gametophyte—(spermatozoid + oosphere) — Sporophyte—(spore)—Gametophyte.

—o—

## Class: Musci or Mosses.

## Type: FUNARIA.* (C. U. 1912, 1914, 1917).

## Description of the Gametophyte.

**Habitat:** *Funaria hygrometrica* grows on hill-sides, damp walls, forests and other similar places. **Morphological structure:** The body of the plant (Fig. 174) is differentiated into *stem, leaves* and root-like structures called *rhizoids*. The stem is slender and slightly branched. The leaf is simple, entire and ovate with a distinct midrib.

**Microscopic structure.**

### Stem.

A transverse section of the *stem* shows the following structures—(1) *Cells* (Fig. 175.ep) on the outside with thick brown walls. From these cells, some *rhizoids* have developed. In the upper part of the stem this superficial layer has not nearly such thick walls and the cells contain some chlorophyll. (2) *Several layers of parenchymatous cells* (Fig.175.tw & tn) whose walls gradually decrease in thickness towards the centre. These cells contain chlorophyll. (3) In the centre, *a group of narrow thin-walled colourless cells* (Fig. 175. cn). These three different kinds of tissues suggest a resemblance to the *epidermis, cortex* and *central stele* of higher plants, but they are not

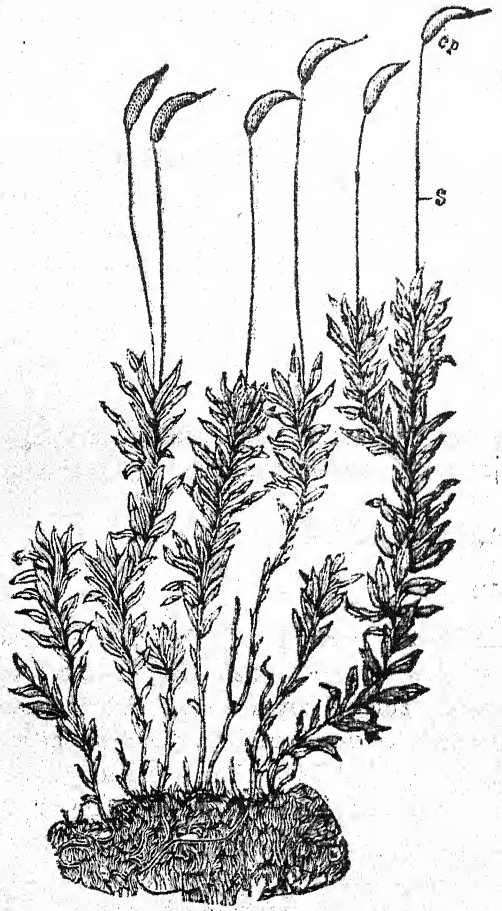



Fig. 174. *A common moss plant.*

Fig. 174.—*A common moss plant.* Shows the branching leafy moss plants (gametophytes) attached to the root-like mass of protonemal filaments and bearing sporophytes (s. cp).

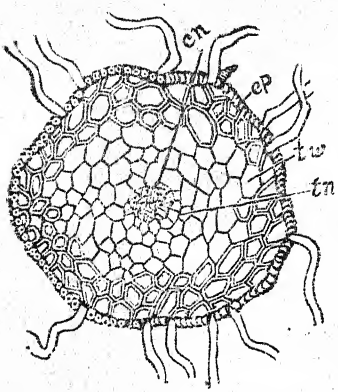



Fig. 175. *Section of Stem of Moss.* *Epidermis* (ep); thick-walled *cortex* (tw); thin-walled *cortex* (tn); central *stele* (cn).

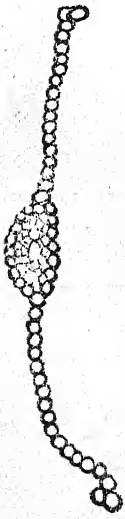


Fig. 176. *Section of Leaf of Moss.*

strictly comparable, as we are dealing with the *gametophyte generation* (moss plant), and these tissues belong to the *sporophyte* of the higher plant.

## Leaf.

A transverse section of a leaf (Fig. 176) shows that it is composed of a *single* layer of chlorophyll—containing parenchymatous cells except at the midrib where it is *several layers* thick and traversed by a *strand of narrow cells* similar to those in the centre of the stem but not directly connected with them. This central strand of narrow cells, both in the stem and leaf, is probably developed to *facilitate the conduction of water.* Mosses are, however, by no means dependent on the passage of water for considerable distances through definite channels for, unlike most plants, they are able to take in water *through their leaves.*

## Rhizoid.

A rhizoid is made up of a row of cells attached together by oblique end walls. It is much branched. When young, it is colourless but its cells may develop chlorophyll if exposed to light; when old, its walls become dark brown.

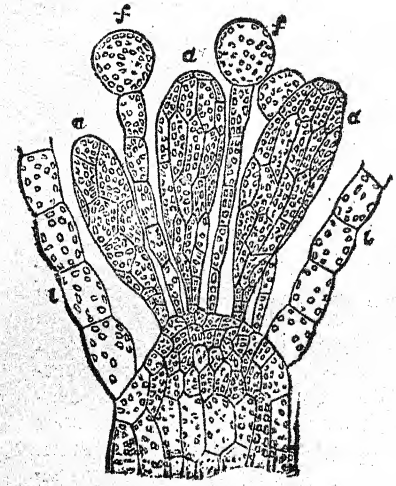



Fig. 177.


Fig 178.

Fig. 177. *Antheridia of Moss—Antheridium* (a); *Leaf* (l) and *Paraphysis* (f).

Fig. 178. Magnified view of an *Antheridium of Moss.—Antheridium* (a); escaping *Spermatocytes* (b); magnified view of a *Spermatocyte* containing a *Spermatozoid.*

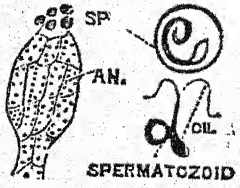



Fig. 179. *Spermatozoid of Moss.* Antheridium (AN); Spermatocytes (SP); Spermatozoid with two cilia (CIL).

## Sexual organs.

Longitudinal sections through the tips of branches show that the male and female organs, the *antheridia* (Fig. 177.a) and *archegonia* (Fig. 180A.a) are formed at the tips of *different* branches covered with *leaves* (Fig. 177.l) and numerous multicellular hairs called the *paraphyses* (Fig. 177. f). Each mature *antheridium* (Fig. 178. a) is a stalked club-shaped structure within which a number of spermatozoid-mother-cells, called the *spermatocytes* (Fig. 178. b&c), are formed. The spermatocytes are liberated through an opening at the top of the antheridium and each of them, on coming out of the antheridium, liberates a *spermatozoid* (male gamete, Fig. 178. c & Fig. 179) which swims about in the water by means of its *two cilia*. Each mature *archegonium* (Fig. 180.B) is a stalked pitcher-shaped body consisting of a swollen basal portion known as the *venter* (Fig. 180B.e) and a long *neck* (Fig. 180B.n). The venter contains the *oosphere* (female gamete, Fig. 180B. o). A large cell, called the *ventral-canal-cell* (Fig. 180 B.vc), lies in the passage between the venter and the

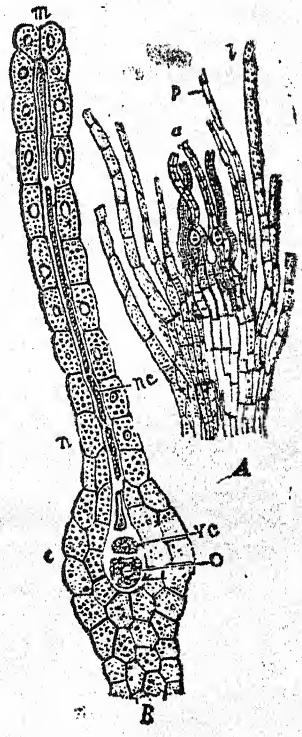



Fig. 180. *Archegonia of Moss.*
A—Longitudinal section through a branch bearing *archegonia* (a); *paraphyses* (p) and *leaves* (l).
B Magnified view of an *archegonium* composed of *venter* (e) containing the *oosphere* (o) and *ventral canal-cell* (vc); *neck* (n) and *neck-canal-cells* (nc); cells (m) closing the cavity of the neck.

canal of the neck which contains many cells called the *neck-canal-cells*(Fig.180B.nc).

## Fertilisation.

When the oosphere is mature, the ventral-canal-cell and the neck-canal-cells degenerate into a mucilaginous substance which contains *cane-sugar* and the scent of which attracts the spermatozoids. One of the spermatozoids at last enters into the venter of the archegonium and unites, after withdrawing the cilia, with the *oosphere ;* the product of union is known as the *oospore* which is surrounded with a wall.

## Development of the Sporophyte.

The oospore, on germination, gives rise to a structure known as the *sporogonium* (Fig. 181.A&B). When the sporogonium has reached a fair degree of development, its upper end swells to form the *capsule* or *theca* (Fig. 182B.sc), and the remainder continues elongating to form the stalk or *seta* (Fig. 182A. s). As it elongates it ruptures the archegonial wall (Fig. 181B.a) the upper portion of which is carried up by the elongating stalk

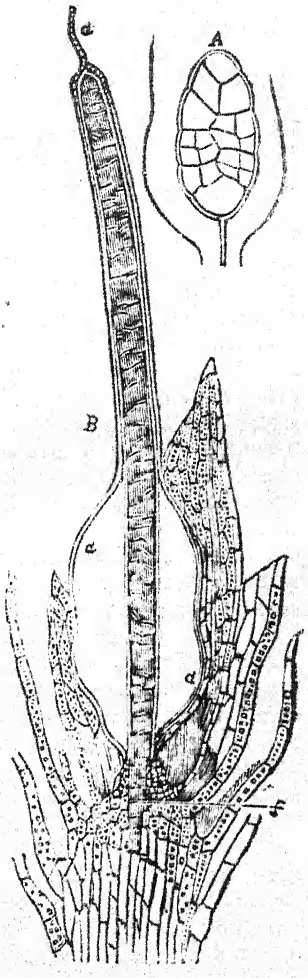



Fig. 181. Developing *sporogonium* of Moss.

and is known as the *calyptra* (Fig. 182B. cal) which forms a detachable cover over the capsule. The lower portion of the ruptured archegonial wall remains as the *vaginula* round the base of the seta. A small structure called the *foot* (Fig. 181B.f)

A—Young *sporogonium*.
B—Older *sporogonium* formed within the *archegonium* (a) and developed *foot* (f) inside the parent-plant.

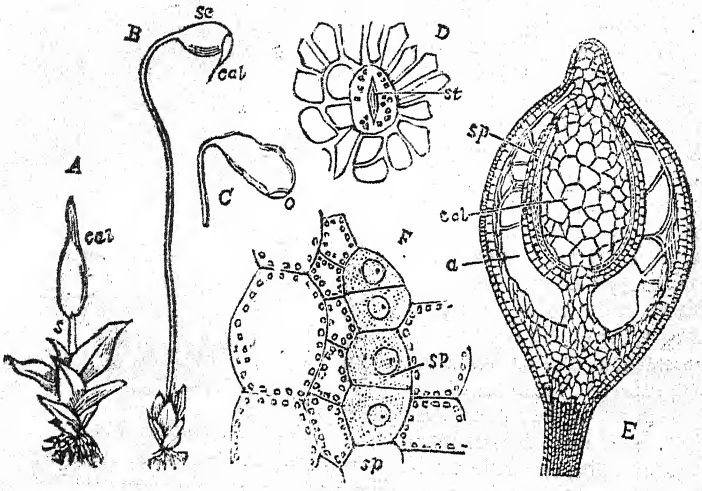



Fig 182. *Sporogonium sporophyte) of Moss.*

A—Young *sporogonium* (sporophyte) attached to the leafy moss plant (gametophyte) by the *seta* (S) upon which is situated the *capsule* with the *calyptra* (cal). B—Older *sporogonium* with mature *capsule* (sc) and *calyptra* (cal) at the tip. C—*Capsule* with the *calyptra* removed showing the *operculum* (o). D—*stoma* (*st*) from the surface of the capsule. E—*Section of a capsule* showing the *columella* (col), *archesporium* (sp) and *air-space* (a). F—*Section of the archesporium* showing the *cells* (sp) which are converted into *spores*.

is developed from the base of the seta; the foot grows into the body of the mother-plant (gametophyte) and the sporogonium (sporophyte) draws nourishment from the mother-plant mainly through the foot. The upper part of the seta, where it joins the capsule, is termed the *apophysis*. The structure of the *seta* is quite simple, consisting of parenchymatous cells, of which the central ones are slightly elongated to form a central conducting tissue. The *capsule* consists of a swollen basal portion and a narrow upper portion. The *swollen basal portion* of the capsule consists of a central mass of barren cells known as the *columella* (Fig. 182E. col). Surrounding the columella, lies the spore-forming tissue known as the *archesporium* (Fig. 182E.sp) which is connected with the wall of the capsule by strands of cells across an *air-space* (Fig. 182E.a). In the lower part of the capsule, below the spore-forming tissue, chlorophyll—containing tissue is more developed and is brought into communication with the air by means of *stomata* (Fig. 182D.st). The

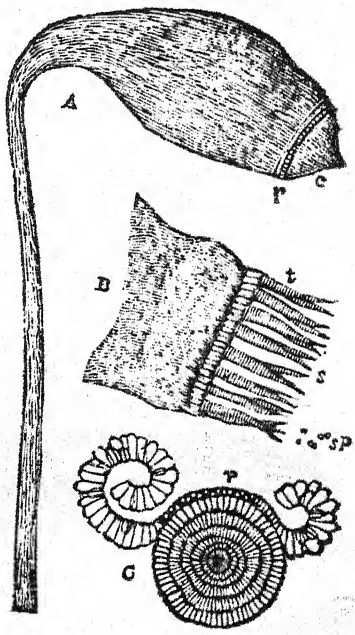



Fig. 183. *Capsule of Moss.*

A—Magnified view of a *capsule* at the top of the *seta* and bearing the *annulus* (r) and *operculum* (c). B—A *portion of the capsule* showing the teeth (t) *of the peristome*; *spores* (sp) coming out of the capsule. C—Magnified view of the *annulus*, the cells of which have absorbed water and have swollen so that the annulus has broken and curled backwards on two sides.

*narrow upper portion* of the capsule contains a lid-like structure known as the *operculum* (Fig. 182C.o & Fig. 183A.c) which is covered over by a membraneous cap called the *calyptra* (Fig. 182B.cal). At the base of the operculum, there is a ring of cuticularised cells constituting a structure known as the *annulus* (Fig. 183A.r). Below the operculum, there is another structure known as the *peristome*. The peristome consists of a circle of pointed triangular structures called teeth (Fig. 183B.t). When the capsule is ripe, the annulus breaks Fig. 183C.r) and the operculum covered with the calyptra falls down. The peristome is then exposed and its teeth, being sensitive to moisture, curl inwards and outwards with changes in the amount of water-vapour in the air and thus help to empty the capsule of its *spores* which are developed in the archesporium.

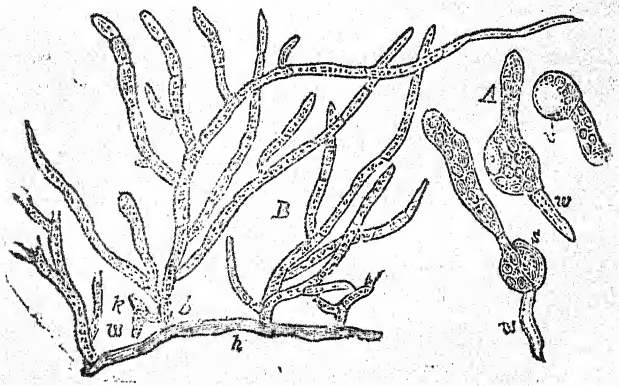



Fig. 184. *Protonema of Moss.*

A—Early stages in the germination of the spore (S) from which a germinating tube (w) is developed. B—*Primary shoot* of the protonema from which branches (b) are developed; upon the branches, *buds* (*k*,w) are developed and each bud develops into a moss plant.

**Development of the Gametophyte.**

Each spore, on germination, produces a multicellular structure called the *protonema* (Fig. 184A & B) upon which numerous *buds* (Fig. 184B.kw) are developed and each bud develops into a Moss plant.

**Alternation of Generations in the Mosses.**

In the life history of a Moss e. g. *Funaria hygrometrica*, we notice two stages or generations—*sexual* and *asexual*. The more conspicuous generation is the sexual or gametophyte (meaning *gamete*-bearing plant) which is represented by the protonema and leafy Moss plant. The gametophyte is followed by the asexual generation or sporophyte (meaning *spore*-bearing plant) which is represented by the *sporogonium* and which is parasitic on the gametophyte. The occurrence of the gametophyte and sporophyte, one after another, in a life history constitutes an "alternation of generations." The life history of Funaria hygrometrica may be expressed by the following formula—

Gametophyte (protonema & moss plant)—(spermatozoid + oosphere) — Sporophyte — (spore) — Gametophyte.

Inter. Questions on "Moss" from 1909—22.

1. Give an account of the life history of any Moss known to you. (C. U. 1912).

2. What do you understand by "alternation of generations"? Illustrate your answer by reference to the moss plant. (C. U. 1914).

3. Describe briefly the life-cycle of a Moss and explain what you understand by alternation of generations. (C. U. 1917).

—o—

# Division : PTERIDOPHYTA
*OR*
# VASCULAR CRYPTOGAMS.


Fig. 185 *Fern plant.*

Fig. 185.A—A part of the creeping stem (*rhizome*, r) from which *rhizoids* (rh), rolled up young *leaves* (*fronds*, fr) and fully expanded leaves (l) are developed. B—Magnified view of one of the *leaflets* showing, on the underside, the *sori* (s) developed over the veins. C—Section through a *sorus* at right angles to the surface of the leaflet showing the *thickness of the leaflet* (P), *placenta* (pl) on which the *indusium* (i) and *sporangia* (s) are developed. D—Magnified view of a *sporangium* consisting of *annulus* (a) and *stomium* (st); *spores* (sp) are coming out by the rupture of the sporangium at the stomium.

## Class: Filicineae.

## Sub-Class: Homosporae.

(Only *one* kind of spore is produced and the prothallus is *free* from the spore).

## Type: ASPIDIUM * (C.U. 1915, 1919, 1920, 1921, 1922).

### Description of the Sporophyte.

Habitat: *Aspidium filix mas* is very abundant in woods and hedgerows.

### Morphological structure.

The body of the plant is differentiated into stem, leaf and root. The *stem* (Fig. 185A.r) is an unbranched rhizome whose surface is completely covered with leaves. Occasionally *buds* are developed on the leaf-bases on the side away from the stem. The young *leaves* (Fig. 185A.f) which cover the tip of the stem are rolled lengthwise from top to bottom and are covered with brown hairs called

the *ramenta* which are also developed on the petioles of the fully expanded leaves. The leaves, when fully expanded, are large and compound. On the underside of the leaflets of some compound leaves, light green or brown patches called *sori* are developed over the veins. The *roots* are adventitious and come off chiefly from the bases of the leaves.

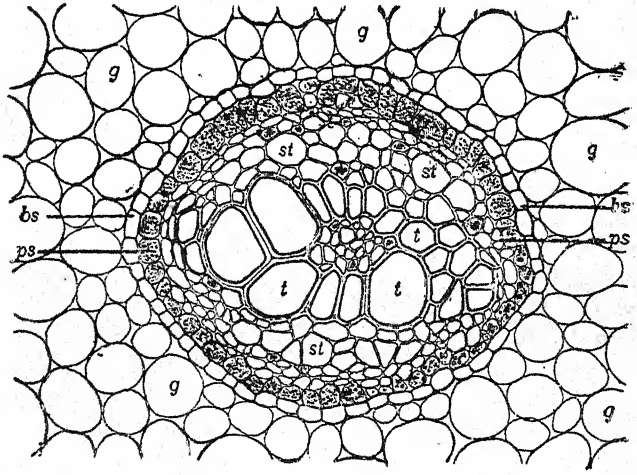



Fig. 186. Vascular bundle of the stem of Aspidium.

Fig. 186. Parenchymatous *ground-tissue* (g); *endodermis* (bs); *pericycle* (ps); *sieve-tubes* (st) *of phloem* surrounding the large thick-walled *tracheids* (t) *of xylem.*

## MICROSCOPIC STRUCTURE.

### Stem.

A transverse section of the *stem* shows successively the following structures from outside towards the centre—(1) Dark-brown *epidermis* (Fig. 187 ep) with cuticularised

cell-walls. Within the epidermis lies the (2) *ground-tissue* (Fig. 186 g & 187 gt) which is composed of thin-walled parenchymatous cells. In the ground-tissue, there are a large number of (3) *vascular bundles* (Fig. 187 VB). Each vascular bundle (Fig. 186) consists of *xylem* (Fig. 186 t)

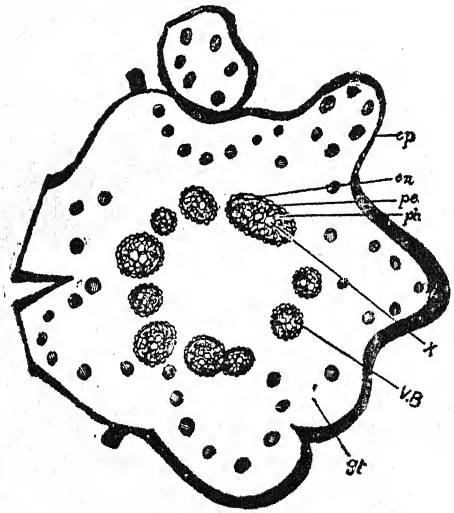



Fig. 187. Section of stem of *Aspidium filix-mas*.

Epidermis (ep) ; Ground-tissue (gt) ; Vascular bundles (VB) ; Pericycle (pe) ; Endodermis (en) ; Phloem (ph) ; Xylem (x).

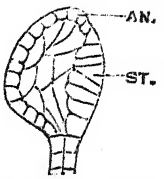



Fig. 188. Sporangium of Fern. Annulus (AN) ; Stomium (ST).

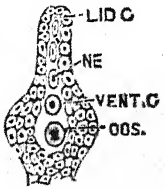



Fig. 189. Archegonium of Fern.

*Lid-cells* (LIDC) ; *Neck-canal-cells* (NE) ; *Ventral-canal-cell* (VENT.C) ; *Oosphere* (oos).

surrounded by *phlœm* (Fig. 186 st). The phlœm is surrounded by a layer of *pericycle* and the pericycle is surrounded by a layer of *endodermis*. The *xylem* consists principally of *scalariform tracheids*, though a few *spiral tracheids* and

a small amount of *parenchyma* are also present. The *phlœm* consists of *sieve-tubes* which are *without callus and companion cells* and which are associated with a very small amount of *parenchyma*. The *pericycle* (Fig. 186 ps) consists of a layer of thin-walled parenchymatous cells. The *endodermis* (Fig. 186 bs) consists of a layer of cells with suberised walls and brown contents.

## Root.

A transverse section of the *root* shows successively the following structures from outside towards the centre—(1) Outermost *protective layer* within which lies the (2) *cortex*, the cells of which are thin-walled towards outside and thick-walled towards inside. The innermost layer of cortex is the well-marked *endodermis*. Within the endodermis, lies (3) a single-layered *pericycle*. Within the pericycle, lies the (4) *stele* which is diarch.

## Leaf.

If a thin transverse section of a *leaflet* is cut *through one of the sori* (Fig. 185 C.P), the following structures can be successively seen from the upper to the lower epidermis—(1) The *upper epidermis*, whose cells are *devoid of stomata* but contain chloroplastids ; (2) The *mesophyll*, consisting of parenchymatous cells rather closer at the top but throughout more or less spongy. The *vascular bundles* are embedded in the tissues of the mesophyll. Each vascular bundle consists of *xylem* and *phlœm* lying side by side and surrounded by the *endodermis*, the xylem lying towards the upper epidermis ; (3) The *lower epidermis*, whose cells contain chloroplastids and *stomata*.

On the lower epidermis and immediately *over a vein*,

there is a tissue known as the *placenta* (Fig. 185 C. pl) on which is developed an umbrella-like structure called the *indusium* (Fig. 185C. i). The indusium covers a number of stalked bodies known as the *sporangia* (Fig. 185C. s) which are also situated on the placenta. Each sporangium (Fig. 185 D & Fig. 188) consists of a thin stalk bearing a swollen head at the top. At the edge of the head of the sporangium, there is an incomplete ring of cells with cuticularised walls ; this ring of cells is known as the *annulus* (Fig. 185 D. a & Fig. 188 AN). Between the end of the annulus and the stalk, there is a structure known as the *stomium* (Fig. 185 D. st & Fig. 188 st) which is composed of thin-walled cells. When the sporangium is mature, the *spores* (Fig. 185 D. sp) are set free from the sporangium by the rupture of the stomium.

## Development and Description of the Gametophyte.

If the conditions of germination are favourable, a spore germinates. Its outer coat bursts and the inner coat grows out into a small green tube (Fig. 190 A) from which a colourless root-hair passes into the soil. The green tube then grows and by repeated cell-divisions forms a heart-shaped structure called the *prothallus* or *prothallium* (Fig. 190 C & D). The central portion of the prothallus is known as the *cushion* which is several cells in thickness, while the rest of the prothallus consists of a single layer of cells. The cells on the underside of the cushion grow out to form unicellular *rhizoids* (Fig. 190 D.rh) by which the prothallus is attached to the soil. The prothallus is self-supporting

because it absorbs raw food materials from the soil by the rhizoids and constructs more complex organic substances by its green colouring matter known as the chlorophyll. The *sexual reproductive organs* are developed on the *underside* of the prothallus. The *antheridia* or *male sexual organs*

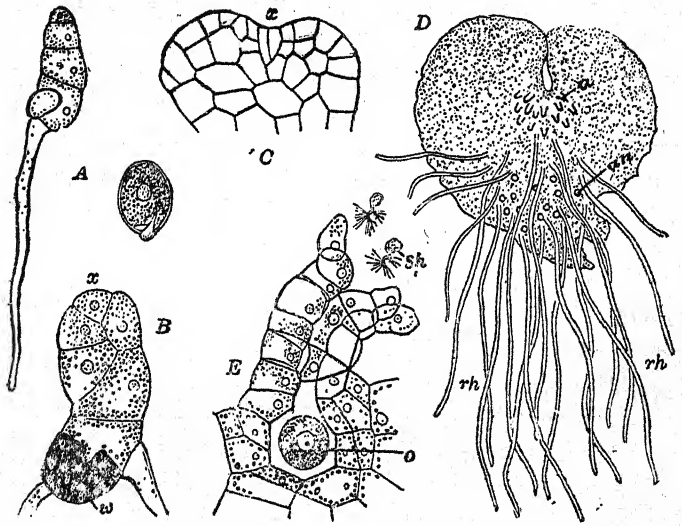



Fig. 190. Fern *prothallium & archegonium.*

A—Stages in the *germination of the spore.* B—Young *prothallium* with the *apical cell* (x) and *remnant of the wall* (*w*) of the spore. C—*Tip of the prothallium* beginning to assume the heart-shaped form. D—*Mature prothallium* with *rhizoids* (rh), *antheridia* (an) and *archegonia* (a). E—An *open archegonium* with the *oosphere* (o) ready for fertilisation and two *spermatozoids* (sp) near the entrance of the neck.

(Fig. 190 D. an) are generally first developed among the root-hairs farther from the notch of the heart-shaped prothallus. Each antheridium is a more or less rounded structure which contains a large number of cells called the

*spermatocytes* or *spermatozoid-mother-cells* within each of which a spirally coiled multiciliate *spermatozoid* (male gamete, Fig. 190 E. sp) is developed. The *archegonia* or *female sexual organs* (Fig. 190 D. a) are developed on the cushion near the notch of the heart-shaped prothallus. Each archegonium (Fig. 190 E) is a flask-shaped organ consisting of two parts :—(1) a cavity in the tissue of the prothallus known as the *venter* which contains the *oosphere* (female gamete, Fig. 190 E. o) and (2) a curved chimney-like tube called the neck which projects beyond the surface of the prothallus. In the immature condition, the free end of the canal of the neck is closed and the canal of the neck contains one or two small cells called the *neck-canal-cells* (Fig. 189 NE). At the junction of the venter and the canal of the neck, there is a large cell called the *ventral-canal-cell* (Fig. 189 VENT. C).

**Fertilisation :** When mature, the antheridium bursts open at the apex and the spermatocytes are set free. Then from each spermatocyte a spermatozoid is liberated which moves about with the help of cilia. When an archegonium is mature, its neck-canal-cells and the ventral-canal-cell degenerate into a mucilaginous substance which contains *malic acid* and which breaks open the closed end of the canal. The scent of the malic acid attracts the spermatozoids, one of which finally enters the venter of the archegonium and unites with the oosphere. The structure thus formed by the union of the spermatozoid with the oosphere is known as the *oospore.* (Generally the spermatozoid of one prothallus unites with the oosphere of another, that is, cross-fertilisation takes place).

## Inter. Questions on "Ferns" from 1909-22.

1. What do you understand by "alternation of generations" in the life history of a plant? Illustrate your answer by reference to the normal course of life history in Ferns (C. U. 1915).

2. Describe the life history of any Fern and clearly state what is meant by "alternation of generations." (C. U. 1919).

3. Describe in detail the sporophyte of a Fern. (C. U. 1920).

4. What do you understand by the expression "life-history of plants"? Illustrate the life history in the case of a Fern. (C. U. 1921).

**Ans.** "Life history of a plant" is the *full account of the life of a plant.* Such an account must contain a complete description of its *habitat, morphological & microscopic structure* and *physiological characters* with special reference to *growth* and *reproduction.*

5. Describe the prothallus of a Fern. What phase does it represent in the life cycle of the Fern? (C. U. 1922).

**Ans.** The *prothallus* represents the *gametophyte phase* in the life cycle of the Fern.

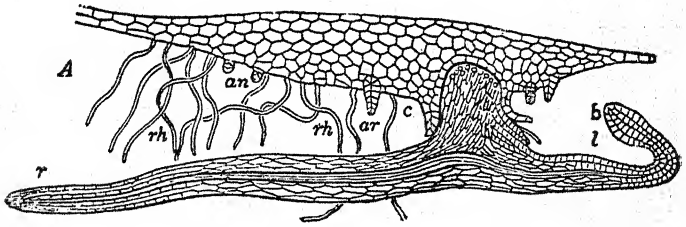



Fig. 191. Development of *sporophyte of Fern.*

A—Section of prothallium with a young sporophyte; *cushion* (c) in which is embedded the *foot*; unfertilised *archegonia* (ar); old antheridia (an); *rhizoids* (rh); first *leaf* (l) of the developing sporophyte and first *root* (r).

## Development of the Sporophyte.

The oospore undergoes repeated divisions and by the cells, thus produced, the *stem, cotyledon* (Figs. 191 & 192 l)

and *root* (Figs. 191 & 192 r) of the young Fern plant (sporophyte) are formed. A structure known as the *foot* (Fig. 191 near c) is also produced; through the foot, the embryo draws nourishment from the prothallium till it is able to feed itself independently.

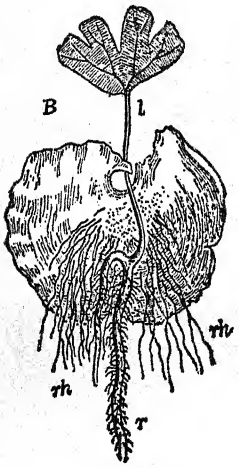



Fig. 192. *Prothallium* with *young sporophyte of Fern.*

First *leaf* (l) has grown up through the notch of the prothallium, while the *root* (r) has entered the earth; rhizoids (rh).

## Alternation of Generations in the Ferns.

In the life history of a Fern (*e.g. Aspidium filix mas*), the *plant itself* represents the *sporophyte generation* as it bears *spores*. The *prothallus* represents the *gametophyte generation* as it bears *gametes* (spermatozoid and oosphere). Since these *two generations* of the plant succeed one another regularly, Fern plant with spores giving rise to prothallus bearing the gametes which cause the formation of the young Fern plant, the life history is said to exhibit "alternation of generations." The life history of a Fern may be expressed by the following formula—

**Sporophyte**→(spore)→**Gametophyte**→(spermatozoid+ oosphere)→**Sporophyte.**
(Fernplant) (Prothallus) (Fern plant).

—o—

## Class : Filicinae.

## Sub-class : Heterosporae.

(Spores are of *two* kinds, large and small. *Large* spore produces *female* and *small* spore produces *male prothallus* which does not become free from the spore).

## Types : SALVINIA, AZOLLA, PILULARIA, MARSILIA.

## Description of the Sporophyte.

### Habitat.

*Salvinia* & *Azolla* are aquatic, floating freely on the surface of water ; *Pilularia* & *Marsilia* are found in bogs and marshes.


Fig. 193. Salvinia.

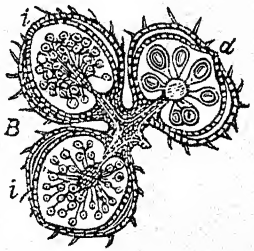



Fig. 194. Sori of Salvinia.

Fig. 193—Part of a plant of *Salvinia*. *Floating leaves* (l) ; *Submerged leaves* (w) ; *apex of Stem* (k) ; *Sori* (s).

Fig. 194—Section through *three sori of Salvinia*. *Two sori* (t, i,) with *microsporangia* ; *sorus* (a) with *macrosporangia*. *Indusium* consists of two layers of cells enclosing an air-space.

### Stem.

The stem is rhizome (Figs. 193, 195, 197 k) ; in *Salvinia*

& *Azolla*, monostelic *without pericycle* but with a *two-layered endodermis ;* in *Pilularia* & *Marsilia*, polystelic at first but eventually gamostelic from the fusion of separate steles to form a ring in which there are *two endodermal bands* (Fig. 196. a & b). In all four genera, the vascular bundles are without cambium and each consists of xylem surrounded by phlœm.

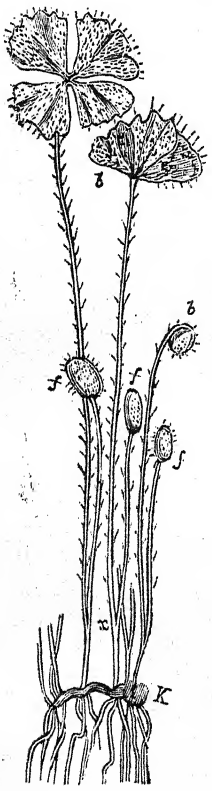



Fig. 195. Marsilia.

Fig. 195—Marsilia plant. *Rhizome* (k), *Sporocarps* (f) springing from the leaf-stalks at (x). Compound leaf (b) consisting of four leaflets.

## Root.

*Salvinia* is rootless ; *Azolla*, *Pilularia* and *Marsilia* bear adventitious roots (193, 195, 197, w).

## Leaf.

In *Salvinia*, there are *three* leaves in a whorl of which *two* are opposite and floating (Fig. 193.l) and *one* is divided into a number of branches (Fig. 193. w) which hang down freely into the water and function as roots ; in *Azolla*, the leaves are alternate and two-lobed, one lobe floating while the other submerged ; in *Pilularia*, the leaves are alternate and cylindrical (Fig. 197. b) and grow vertically upwards ; in *Marsilia*, the leaves are alternate and com-

pound, a long petiole bearing *four* leaflets vertically upwards (Fig. 195. b). In *Salvinia* and *Azolla*, the sori( Fig. 193. s) are developed on the submerged leaves or lobes of leaves. Each sorus consists of a *placenta* (Fig. 194) on which are developed the *sporangia* which are completely closed by an *indusium* composed of two layers of cells ; in *Salvinia*, there is an air-space between the two layers of cells. There are *two* kinds of sporangia. One, known as the *micros-*

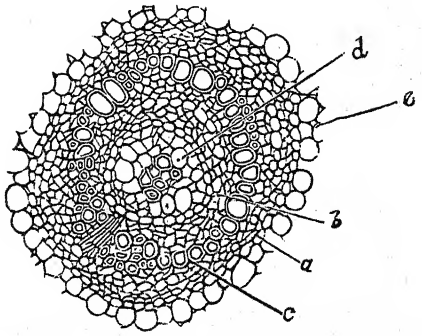



Fig. 196. Section of *Stele of Marsilia.*

Fig. 196—Stele of Marsilia showing *gamostelic* structure. *Outer endodermis* (a) ; *inner endodermis* (b) ; fused *xylem* bundles (c) ; *fundamental tissue* (d) isolated by the fusion of the steles ; *cortex* (e).

*porangium* (Fig. 194.i), contains small *spores* called *microspores ;* the other, known as the *macrosporangium* (194.a), contains large spores called *macrospores* or *megaspores.* Each sorus consists either of microsporangia or macrosporangia but never contains both (Fig. 194). In *Pilularia* and *Marsilia,* the sporangia are formed in a complex structure known as the *sporocarp* which is developed, in *Marsilia* (Figs. 195 f), on a stalk springing from the

petiole of a leaf and, in *Pilularia* (Fig. 197.f), from the rhizome. The interior of each sporocarp is divided into a number of chambers each of which contains a *sorus* (Fig. 198. A). Each sorus contains both *microsporangia* and *macrosporangia* (Fig. 198.D & E). The sporocarp is made to rupture by the mucilaginous character of the internal tissue which absorbs water and causes the wall of the sporocarp to split.

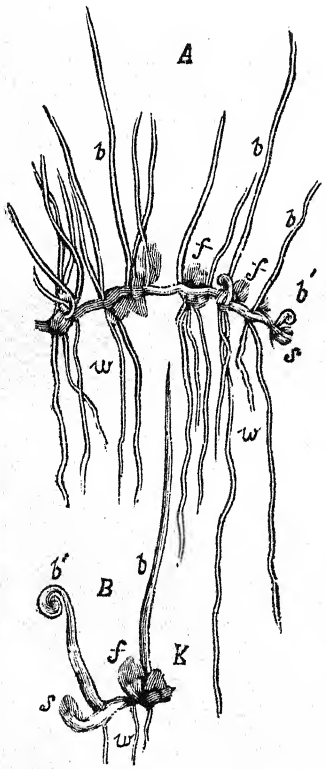



Fig. 197. Pilularia.

A—Natural size of the plant. B—Magnified view of the end of shoot showing *Apex* (s) of the stem, *leaves* (b, b',), *Roots* (w) and *Sporocarps* (f).

## Spores.

*Microspore.*

In *Salvinia*, all the *microspores* are joined together; in the sporangium of *Azolla*, there are from 2 to 8 masses, each containing the microspores and being known as the *massula*. Each massula is surrounded by a delicate skin which, in some species, possesses hair-like structures known as the *glochidia*. In *Pilularia* and *Marsilia*, the microspores are free from each other but each spore, instead of possessing only two

walls, has a third wall known as the *epispore* or *perinium.*

*Macrospore.*

In *Salvinia, Pilularia* and *Marsilia,* the *macrospores* are free but each possesses an *epispore* like the microspore of Pilularia and Marsilia. In *Azolla,* the epispore, on the lower surface of the macrospore, is developed into a large spongy mass which acts as a float, while the upper surface is firmer and bears filamentous outgrowths. The apex of the spore is generally furnished with a number of delicate filaments extending between the floats. The glochidia of the massulæ of microspores generally catch these filaments so that the massulæ are anchored to the macrospore.

## Development and Description of the Gametophyte

**Male prothallium or male gametophyte.**

In *Salvinia* and *Azolla,* the *microspore* germinates and puts out a tubular protrusion of the inner wall. This tubular structure is the *male prothallium.* From this, a terminal cell is cut off which divides into two. These two cells divide and produce a rudimentary *antheridium* within which *four spermatocytes* (spermatozoid-mother-cells) are produced. The spermatocytes, on attaining maturity, come out of the antheridium and escape into the water. Subsequently, one *spermatozoid* is liberated from each spermatocyte. In *Pilularia* and *Marsilia,* the *microspore* divides into *two* cells, one large and the other small. The large cell is the *antheridial cell* and the small cell is the

*vegetative cell.* The antheridial cell divides and produces *eight* cells, each of which forms a *spermatozoid.*

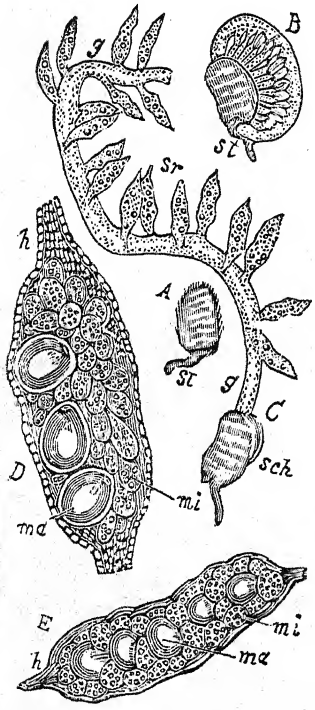



Fig. 198. Sporocarp of Marsilia. A—a *sporocarp.* B—a *sporocarp* which has burst the gelatinous ring and is protruding through it; C—the gelatinous ring has ruptured and extended, showing the separated *sori* (s); D & E—*Sori* containing *microsporangia* (mi) and *macrosporangia* (ma).

**Female prothallium or female gametophyte.**

In all four genera, the *macrospore* begins to germinate before its coats rupture. It divides into two cells, one large and the other small, by a wall known as the *diaphragm.* The small cell divides and produces a small tissue which soon comes out of the spore-coats owing to the rupture of the latter and becomes green. This tissue is the *female prothallium.* The large cell remains almost unchanged, becoming filled with various reserve materials for the nutrition of the young embryo which is subsequently developed in the prothallium. At the apex of the female prothallium, usually *three archegonia* (female organs) are developed in *Salvinia,* and only *one* in *Azolla, Pilularia* and *Mar-*

*silia.* If none of the first-formed archegonia becomes fertilised, more are developed later. The structure of the archegonium is similar to that of a homosporous Fern e.g. *Aspidium filix mas.* The female cell (*oosphere*) is fertilised by a male (*spermatozoid*) and the product of union is the *oospore.*

## Development of the Sporophyte.

The oospore germinates and produces, in *Salvinia, one cotyledon* known as the *scutiform leaf, stem* and *foot* but *no root ;* in *Azolla, Pilularia* and *Marsilia, two cotyledons, stem, root,* and *foot.*

—o—

## Class : Equisetinae.

## Type : EQUISETUM.

## Description of the Sporophyte.

### Habitat.

*Equisetum arvense* is widely distributed over the globe.

### Morphological Structure.

The stem is a rhizome which is differentiated into distinct *nodes* and *internodes.* From the nodes of the rhizome, whorls of small *scale-leaves,* a number of *adventitious roots* (Fig. 199.A) and a few *buds* are developed. Sometimes the internodes of the rhizome may develop into swollen *tubers* (Fig. 199 A.t) which, on being detached from the parent plant, may propagate the plant. From the underground rhizome, *shoots* (*vegetative* and *reproductive*) grow

up into the air. The vegetative shoots (Fig. 199.B) are green and are marked with ribs which alternate in successive internodes. Each vegetative shoot is also divided into *nodes* and *internodes* and at each node, there is a whorl of

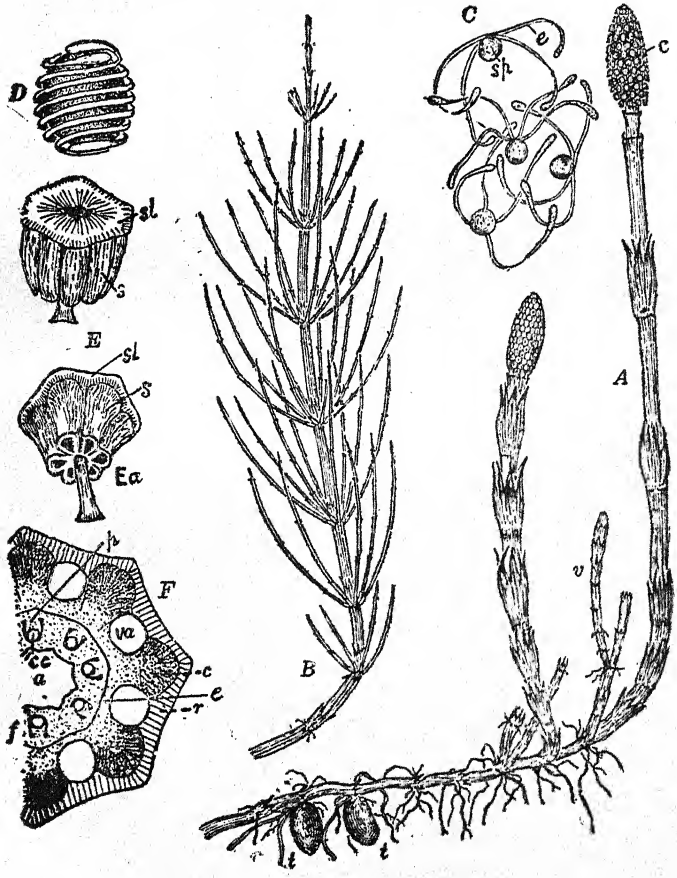



Fig. 199. Equisetum arvense.

Fig. 199. A—*Fertile shoot* developed from the *rhizome* and bearing *cones* (c) at the apex ; *tubers* (t) developed from the rhizome ; young *vegetative shoot* (v) developed from the rhizome and ready to grow into a mature structure as shown in (B). B—A *vegetative shoot.* C—A group of *spores* (sp) with their *elaters* (e) expanded. D—A *spore* with the elaters coiled around it. E & Ea—Two views of a *sporophyll* (sl) with the group of *sporangia* (s). F—Portion of a section of *vegetative shoot* showing *epidermis, cortex* consisting of *sclerenchymatous tissue* (r) below the epidermis, *chlcrophyll-containing* tissue (c), *vallecular cavities* (va) and *endodermis* (e) ; *vascular bundles* (f) around an *air-space* (a) ; *carinal cavity* (cc) of the *xylem* of the vascular bundle and *phloem* (p).

small *scale-leaves* which are united with each other (Fig. 199.B). *Buds* are developed in the axils of the scale-leaves and each bud develops into a *branch ;* thus a *whorl of branches* is formed at each node (Fig. 199.B). The reproductive shoots contain little or no chlorophyll and are hence dependent on the rhizome for food materials. Each of the reproductive shoots is unbranched and bears terminally a number of spirally arranged *sporophylls* (Fig. 199.A). The sporophylls are considered by some Botanists as *sporangiophores* as evidence obtained from fossil plants seems to point to their being more strictly comparable to *branches* rather than to *leaves.* The terminal portion of the reproductive shoot bearing the sporophylls is known as the *cone* (Fig. 199 A.c). At the bottom of each cone, there is a whorl of sterile leaves constituting the *annulus.* Each sporophyll consists of a short stalk bearing at the top a flat hexagonal disc to the underside of which, *five* to *ten sporangia* are attached (Fig. 199. E&Ea.sl&s). The sporangia contain numerous *spores* which are *all of one kind* and which are shed when the sporangia are mature. The

reproductive shoots wither away as soon as the sporangia shed their spores.

## Microscopic Structure.

**Vegetative shoot.**

Proceeding from outside towards the centre, the following tissues can be successively seen in a *vegetative shoot*— (1) A wavy *epidermis* with cuticularised wall which is strongly impregnated with *silica*; *stomata* occur on the epidermis. (2) A discontinuous band of *sclerenchyma* (Fig. 199F. r) occurs beneath the epidermis. (3) The general *cortex* containing air-spaces called *vallecular cavities* (Fig. 199F. va); groups of cells of the general cortex contain *chlorophyll* (Fig. 199F. c). (4) The *endodermis* (Fig. 199F. e). (5) Strands of *vascular bundles* (Fig. 199F. f). Each vascular bundle consists of *xylem* and *phlœm* lying side by side. The *xylem* is V-shaped with the apex pointing towards the centre of the shoot and the limbs pointing outwards. The *primary xylem* is composed of *scalariform tracheids* and a small amount of *parenchyma*; the *protoxylem* borders on the *carinal cavity* (Fig. 199F. cc) of the xylem and consists of a few *spiral* and *annular tracheids*. The *primary phlœm* (Fig. 199F. p) lies between the limbs of the V-shaped xylem and is composed of *sieve tubes* and *parenchyma*. (6) In the centre of the shoot, there is a *cavity* (Fig. 199F. a); at the growing point, *pith* occurs in the place of such a cavity.

**Rhizome.**

A transverse section of the *rhizome* differs from that of the *vegetative shoot* in having, over its whole surface, a *thick band of sclerenchyma* with numerous *brown hairs*.

*Stomata* and *chlorophyll-containing tissue* are absent. *Pith* is present and hence the *central cavity* is absent.

**Root.**

Proceeding from outside towards the centre of the root, the following tissues can be successively seen—(1) The *epiblema.* (2) The *general cortex* differentiated into outer dark-coloured cells and inner colourless cells with large intercellular spaces. (3) *Two-layered endodermis* completely enclosing the (4) *vascular bundles* consisting of *three* or *four patches of primary phlœm* alternating with the same number of *patches of primary xylem.* The centre of the root is occupied by a *large tracheid.*

**Leaf.**

Each leaf has a single *collateral bundle without carinal cavity* and surrounded by an *endodermis.* The tissues outside the endodermis are similar to those described under the vegetative shoot.

**Spore.**

The spores contain abundant *chlorophyll.* Each spore has a four-layered wall. The outermost layer, known as the *episporium,* consists, when the spore is ripe, of four spiral bands, called *elaters* (Fig. 199. C&D), attached at one point. The elaters, under moist conditions, are wrapped round the spore, and under dry conditions, open out. The movement of the elaters no doubt helps in the dehiscence of the sporangium.

## Development and Description of the Gametophyte.

The spores germinate almost directly they are shed. From each spore, a multicellular *prothallium* and *rhizoids*

(Fig. 200 A&C. r) are formed. The prothallia, when fully developed, are of very irregular form and vary much in size. The prothallia generally produce either *archegonia* or *antheridia* but not both. The *larger prothallia bear only archegonia* (Fig. 200C. ar) or female organs and the *smaller prothallia bear only antheridia* (Fig. 200A. an) or male organs. The archegonia and antheridia are similar in form and development to those of a Fern e.g. *Aspidium filix mas* (See p. 384). At first they are on the lower side of the prothallium, but as the lobes of the prothallium grow larger they get pushed up to the upper surface. The *oosphere* (female cell) of the archegonium is then fertilised by a *spermatozoid* or male cell (Fig. 200. B). The oosphere, after fertilisation, is known as the *oospore*.

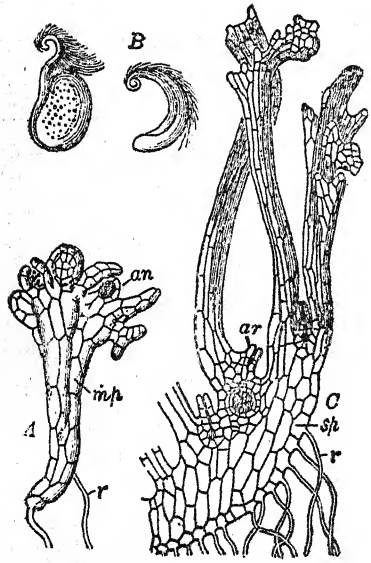



Fig. 200. Gametophyte of Equisetum.

Fig. 200. A—*Male prothallium* (mp), *rhizoid* (r), *antheridium* (an). B—*Spermatozoids*. C—*Female prothallium* (sp), *rhizoid* (r), *archegonium* (ar).

## Development of the Sporophyte.

The oospore divides repeatedly and from the cells thus produced, the *stem*, *two cotyledons* and the *root of the embryo*

are produced. A structure, called the *foot*, is also produced ; the foot serves to attach the embryo to the prothallium until it is sufficiently developed to maintain itself.

## Alternation of Generations in the Equisetum.

In the life history of an *Equisetum*, the *plant itself* represents the *sporophyte generation* as it bears *spores*. The male and female *prothallium* represent the *gametophyte generation* as they bear *gametes* (spermatozoid and oosphere). Since these *two generations* of the plant succeed one another regularly, Equisetum plant with spores giving rise to male and female prothallium bearing the male and female gametes which cause the formation of the young Equisetum plant, the life history is said to exhibit " alternation of generations." The life history of an Equisetum may be expressed by the following formula—

Sporophyte → (spore) → Gametophyte → (spermatozoid + oosphere) →
(Equisetum plant) (Male & female prothallium)

Sporophyte.
(Equisetum plant)

——o——

## Class : Lycopodinae.

### Sub-class : Homosporae.

## Type : LYCOPODIUM.

### Habitat.

*Lycopodium clavatum* is distributed all over the world.

### Morphological Structure.

The main stem (Fig. 201) and its stouter branches are creeping. The leaves are developed, in some places in

whorls and in others spirally, from the sides of the stem and branches. The leaves are of two kinds—vegetative and spore-bearing. The *vegetative leaves* are simple, linear with hairy margins and end in a long thread-like point (Fig. 201 & Fig. 203. st). The spore-bearing leaves or *sporophylls* (Fig. 203C. sp) are rather broader than the vegetative leaves and are closely crowded together at the tips of branches ; the tip of the branch bearing the sporophylls is known as the **cone** (Fig. 201. c). At the base of each sporophyll, there is a *sporangium* (Fig. 203.C. s)

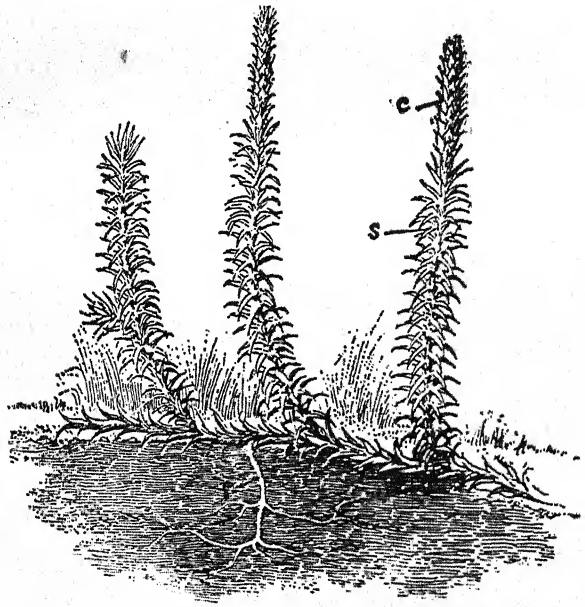



Fig. 201. Lycopodium plant.

Cone (c) ; Vegetative leaves (s) ; Much branched root embedded in the soil.

which dehisces and sets free large quantities of fine yellow *spores* known as the " Lycopodium dust."

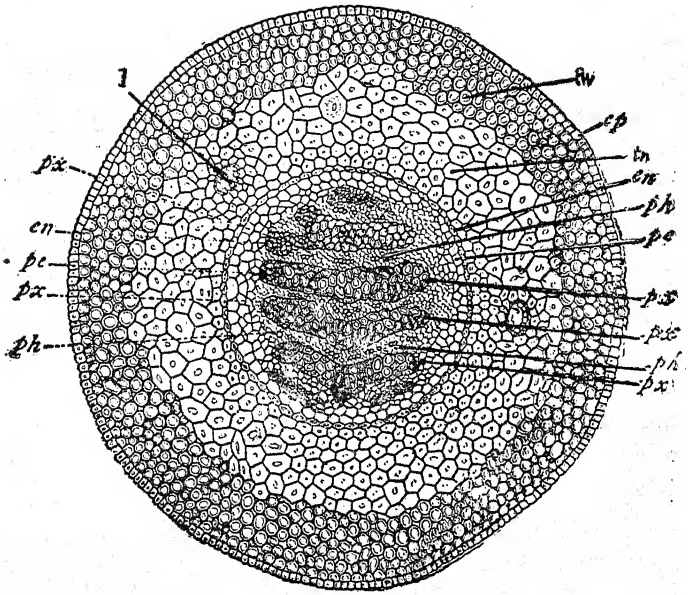



Fig. 202. Section of the Stem of Lycopodium.

Epidermis (ep) ; Thick-walled cortex (tw) ; Thin-walled cortex (tn) ; Leaf-trace bundle (l) ; Endodermis (en) ; Pseudo-pericycle (pe) ; Protoxylem (px) ; Protophloem (ph).

## Microscopic Structure.

### Stem.

Proceeding from outside towards the centre of the stem, the following tissues can be successively seen—(1) The *Epidermis* (Fig. 202. ep)which is strongly cuticularised. (2) The *Cortex* (Fig. 202.tw & tn) which is composed of cells whose walls exhibit different degrees of thickening in

different layers. Scattered throughout the cortex, there are *leaf-trace bundles* (Fig.202.l). (3) Several layers of cells which by some authorities are regarded as *pericycle* and by others as *endodermis* (Fig. 202.en&pe). (4) *Plates of xylem* (Fig. 202.px) alternating with *plates of phlœm* (Fig. 202.ph). The xylem plates, which lie more or less horizontally, are joined up with one another at intervals and consist of *scalariform tracheids ;* the *protoxylem* (Fig. 202.px) occurs at the outer extremity of the plate of xylem. The *protophlœm* is also external and, passing inwards, the *phlœm* consists of cells with larger cavities.

## Leaf.

There are *stomata* on both the surfaces of the leaf. The *mesophyll* of the leaf consists of chlorophyll—containing parenchymatous tissue in which is embedded a single small *vascular bundle.*

## Root.

The structure of the root resembles that of a Lycopodium stem with about *three xylem plates* alternating with the *same number of phlœm plates.*

## Sporangia and Spores.

Each *sporangium* (Fig. 203 B&C. s) is developed at the base of a *sporophyll* (Fig. 203 B&C. sp) and consists of a short *stalk* bearing ,at the apex, a swollen head. The *spores* (Fig. 203 D. t), which are *all of one kind,* are formed within the sporangium.

## Development and Description of the Gametophyte.

The *prothallium* (Fig. 204.A) shows considerable variety of form. It is a small tuberous body with a colourless

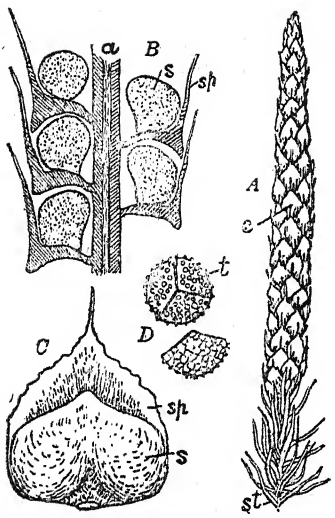



Fig. 203. Cone of Lycopodium.

A—*Cone* (c) consisting of overlapping sporophylls ; *Branch* (St) at the bottom of the cone bearing green needle-shaped vegetative leaves. B—A portion of longitudinal *section through the cone* consisting of *axis* (a), *sporophylls* (sp) bearing *sporangia* (s). C—The inner face of a *sporophyll* bearing the large *sporangium*. D—Two views of *spores* (t) from a group of four.

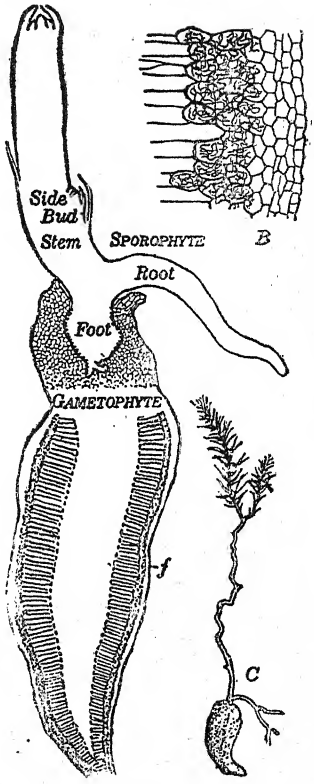



Fig. 204. Prothallium (gametophyte) with the developing Sporophyte of Lycopodium.

A—*Prothallium* (f) with young Sporophyte. C—Young *Lycopodium plant* still attached at the base to the bean-shaped subterranean prothallium (gametophyte).

base, from which *unicellular rhizoids* are developed, and an apex which is divided into several green lobes ; in others, it is altogether tuberous. In other species, it is larger and is a cylindrical branched body bearing gametophores. The prothallium bears both *archegonia* and *antheridia* which resemble the corresponding organs of Ferns like *Aspidium* (See p. 384) excepting that the *spermatozoids are biciliate and the archegonia contain a larger number of neck-canal-cells.*

## Development of the Sporophyte.

The oospore divides into two cells—*hypobasal* cell and *epibasal* cell. The hypobasal cell slightly elongates to form the *suspensor.* The epibasal cell divides and gives rise to the *embryo* which consists of a *primary stem* (Fig. 204.A) bearing a *single cotyledon.* The part of the axis of the embryo below the cotyledon is sometimes known as the *foot* (Fig. 204.A). An *adventitious root* (Fig. 204.A) develops from below the cotyledon.

—o—

## Class : Lycopodinae.

Sub-class : Heterosporae.

## Type : SELAGINELLA.*

## Description of the Sporophyte.

### Habitat.

*Selaginella kraussiana* inhabits the damp forests of tropical countries.

## Morphological Structure.

The *stem* is creeping and almost dichotomously branched (Fig. 205). At the points at which normal branching takes place, leafless *branches,* termed *rhizophores* (Fig. 205.H), are developed. The rhizophore is regarded as a branch because, like a branch, it is developed from the outer tissues of the stem, it has no root—cap whereas the true root of Selaginella has one, and it sometimes develops


Fig. 205. Selaginella plant. *Rhizophore* (H) ; *Cone* (S).

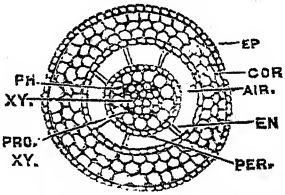



Fig. 206. Section of Stem of Selaginella.

*Epidermis* (EP); *Cortex* (COR); *Air-space* (AIR); *Endodermis* (EN); *Pericycle* (*PER*); *Xylem* (XY); *Protoxylem* (PRO. *XY*); *Phloem* (PH).

leaves and sporophylls. The rhizophore is regarded by some as a root because its internal structure is more like that of a root than that of a branch. At each node, there are *two leaves,* one *large* and the other *small* (Fig. 209A. sl & l). Each leaf is small, simple, sessile and with a distinct midrib. On the inner side of each leaf, there is a small scaly outgrowth known as the *ligule.* The spore-bearing leaves or *sporophylls* (Fig. 205.S& Fig. 209 A.B.D) occur at the apex of some branches which grow straight upwards ; the

sporophyll-bearing portion of such a branch is known as the *cone* or *spike* (Fig. 209 A.c).

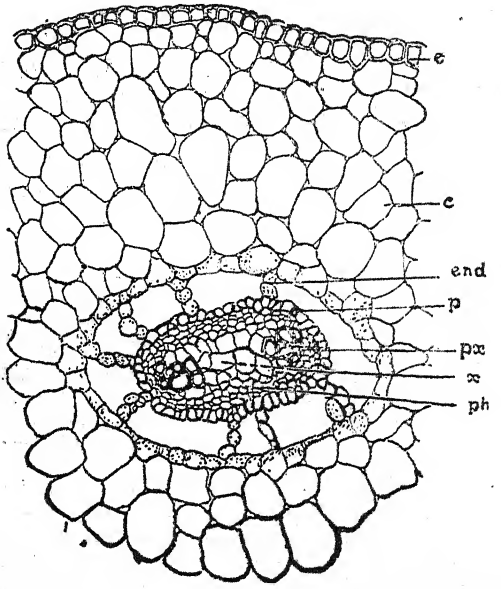



Fig. 207. Section of the Stem of Selaginella.

*Epidermis* (e) ; *Cortex* (*c*) ; *Endodermis* (end) ; *Pericycle* (p) ; *protoxylem* (px) ; *Xylem* (x) ; *Phloem* (ph).

## Microscopic Structure.

### Stem.

Proceeding from outside towards the centre of the stem, the following tissues can be successively seen—(1) The *Epidermis* (Figs. 207 & 208.e) consists of thick-walled parenchymatous tissue. (2) The *Cortex* consists of *sclerenchyma* (Fig. 208.s) and thin-walled parenchymatous cells

(Figs. 207 & 208.C.). (3) The *Endodermis* is represented by strands of cells (Fig. 207. end & Fig. 208.en) across an

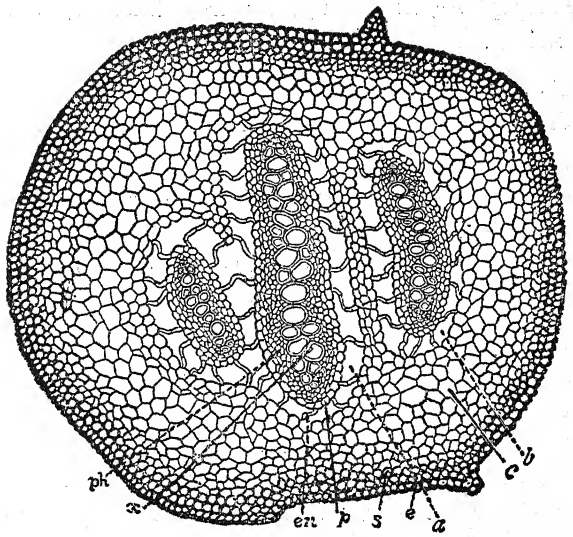



Fig. 208. Section of the Stem of Selaginella.

*Epidermis* (e) ; *Sclerenchyma* (s) ; *Cortex* (c) ; *Endodermis* (en) ; *Air*-space (a & b) ; *Pericycle* (p) ; *Phloem* (ph) ; *Xylem* (x).

*air-space* (Fig. 208.a&b) and holds (4) *one* (Fig. 207) two or *three steles* (Fig. 208). The stele is surrounded by the *pericycle* (Figs. 207 & 208.p) and consists of *xylem* (Figs. 207 & 208. x) surrounded by *phlœm* (Figs. 207 & 208.ph). The xylem is developed centripetally like the root of higher plants and hence the *protoxylem* (Fig. 207.px) lies outside. The xylem is composed mainly of sclalariform tracheids and the protoxylem is made up of spiral and annular tracheids.

## Root and Rhizophore.

Both in the *root* and *rhizophore*, there is a single *stele* which contains only *one group of xylem* and *one of phlœm*. The rhizophore, as distinguished from the root, is peculiar in having a *central protoxylem*.

## Leaf.

The leaves are of simple structure. The *midrib* consists of *xylem* surrounded by *phlœm* which is again surrounded by the *endodermis*. *Stomata* occur on the lower epidermis. Both upper and lower epidermis as well as the mesophyll between them contain but few chloroplastids, sometimes only one of an unusually large size.

## Cone.

A *longitudinal section of the Cone of Selaginella* (Fig. 209.F) shows that in the axil of each sporophyll, there is a *sporangium*. The sporangia, in the axils of the *upper* sporophylls, are known as *microsporangia* (Fig. 209 F.s. & D.sp) because they contain very small spores called *microspores* (Fig. 209 E.s) ; the sporophyll bearing a microsporangium is known as *microsporophyll* (Fig. 209 D & F. sl). The sporangia, in the axils of the *lower* sporophylls, are known as *macrosporangia* (Fig. 209 B & F.mgs) because they contain comparatively larger spores called *macrospores* (Fig. 209 C & F.ms) ; the sporophyll bearing a macrosporangium is known as *macrosporophyll* (Fig. 209 B & F.ml). In the sporangium, there is a central mass of cells known as *archesporium* which is surrounded by several layers of cells constituting the *tapetum*. The cells of the archesporium divide and produce several cells called *spore-mother-cells*. Each spore-mother-cell of a microsporangium pro-

duces *four microspores* (Fig. 209 E.s) but in the case of macrosporangium, only *one* spore-mother-cell produces *four macrospores* (Fig. 209 F.ms), the rest remain functionless.

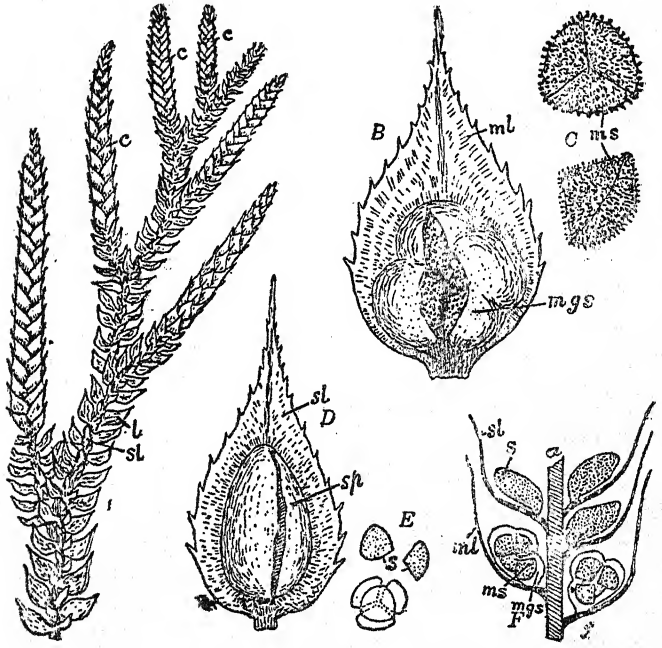



Fig. 209. Cone of Selaginella.

A—Branch bearing *cones* (c) and *small* (sl) and *large leaves* (l). B—Inner face of a *macrosporophyll* (ml) bearing at the base a large *macrosporangium* (mgs) containing a group of *four macrospores*. C—Two views of *macrospores* (ms). D—Inner face of a *microsporophyll* (sl) bearing at the base a *microsporangium* (sp). E—*Microspores* (s). F—*Longitudinal section of a cone* showing the *axis* (a) bearing the *microsporophylls* (sl) at the top and *macrosporophylls* (ml) at the bottom; the microsporophyll bears on the upper surface the *microsporangium* (s) and the macrosporophyll bears on the upper surface the *macrosporangium* (mgs) containing *four macrospores* (ms).

When the microsporangia and macrosporangia are ripe, their walls rupture and the microspores and macrospores come out and fall to the ground.

## Development and Description of the Gametophyte.

**Male prothallium or male gametophyte.**

At the time of germination, each *microspore* first of all divides into two cells, one *small* and the other *large*. The *small cell* is the *vegetative cell* (Fig. 210 A.p) which does not undergo any further division, whereas the *large cell* undergoes repeated divisions and produces a single *antheridium*. Within the wall of the antheridium, the *spermatozoid-mother-cells* are produced (Fig. 210 A.s) and within each spermatozoid-mother-cell, a *biciliate* slightly twisted *spermatozoid* (Fig. 210 B.sp) is produced. When the spermatozoids are mature, the coats of the microspore as well as the wall of the antheridium burst, and the spermatozoids are set free.

**Female prothallium or female gametophyte.**

The female *prothallium* is developed inside the *macrospore*. At the time of germination, the macrospore divides into a *small* upper cell and a *large* lower cell. The *small upper cell* divides and forms a *small-celled* tissue (Figs. 210 & 211) which bursts out a portion of the wall of the macrospore and develops chloroplastids at the part which is exposed to light. At the exposed portion of this small-celled tissue, only one *archegonium* (Fig. 210 C.a & 211.arch) is developed ; if the first archegonium fails to become fertilised, a few others may be subsequently formed. Each archegonium consists of a *small neck* and a *venter*. The neck contains

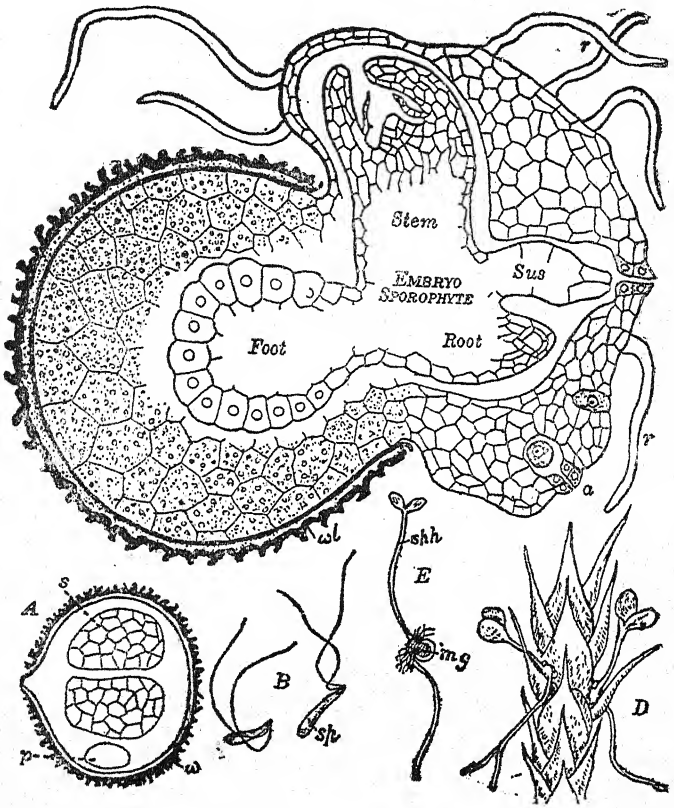



Fig. 210. Prothallia of Selaginella.

A—*Male prothallium* within the *microspore*; *wall* (w) of the microspore; persistent *nucleus* (p) of the *vegetative cell*; *antheridium* composed of two groups (s) of *spermatozoid-mother-cells*. B—Two *biciliate spermatozoids* (sp). C—*Female prothallium* developed by rupturing a portion of the wall of macrospore; remaining portion of the *wall* (wl) of the macrospore; *archegonium* (a); *rhizoids* (r); *suspensor* (Sus), *Stem*, *Root* and *Foot* of the *Embryo-Sporophyte*. D—Young *sporophyte* held by the sporophylls of the cone. E—*A young sporophyte* (sph) still attached to the *macrospore* (mg).

a single cell called the *neck-canal-cell*. Between the canal of the neck and the cavity of the venter, there is another cell called the *ventral-canal-cell*. The *oosphere* lies within the venter which is, in fact, a cavity in the tissue of the female prothallium. The *large lower cell* divides and produces a *large-celled* loose tissue (sometimes called *endosperm*) which is rich in reserve food materials. The cell-walls at the junction of the small-celled and large-celled tissue thicken and form a partition-wall known as the *diaphragm* (Fig. 211).

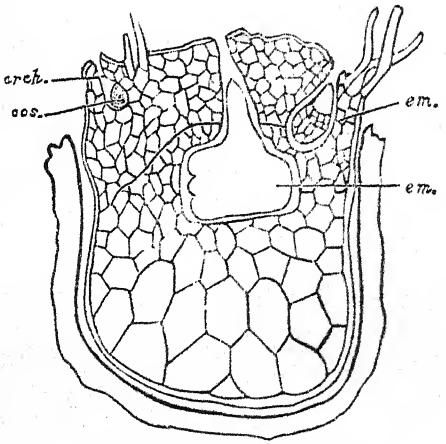



Fig. 211. Germination of macrospore of Selaginella.
*Archegonium* (arch) ; *Oosphere* (oos) ; *Young embryos* (em', em) ; *Diaphragm* is the dark partition-wall at the junction of small and large-celled tissue.

## Fertilisation.

When the oosphere attains maturity, the neck-canal-cell and the ventral-canal-cell degenerate into a mucilaginous

substance which, after breaking open the closed end of the canal of the neck, attracts the spermatozoids by its peculiar scent. One of the spermatozoids enters into the archegonium and unites with the oosphere. The product of union is the *oospore* which is subsequently surrounded with a wall.

## Development of the Sporophyte.

The oospore divides repeatedly and from the cells thus produced, a structure called the *suspensor* (Fig. 210 C.Sus), the *hypocotyl*, the *stem* and the *two cotyledons* of the *embryo* are produced (Fig. 210.C). A false *foot* is developed from near the hypocotyl and the first *root* (Fig. 210.C) is developed from the cells between the foot and the suspensor. The foot remains embedded in the tissue of the endosperm and absorbs food materials from the endosperm.

## "Alternation of Generations" in Selaginella.

In the life history of a Selaginella, we notice two stages or generations—*asexual* and *sexual*. The more conspicuous generation is the asexual or **sporophyte** (meaning *spore*-bearing plant) which is represented by the Selaginella plant. The sporophyte is followed by the sexual generation or **gametophyte** which is represented by the male and female prothallium. The occurrence of the sporophyte and gametophyte, one after another, in a life history constitutes an " alternation of generations." The life history of a Selaginella may be expressed by the following formula—

**Sporophyte**→(spore)→**Gametophyte**→(spermatozoid + oosphere)→**Sporophyte.**

——o——

## Sub-division : Gymnosperms or Gymnospermae.

### Order : Cycadales.

## Type : ZAMIA.

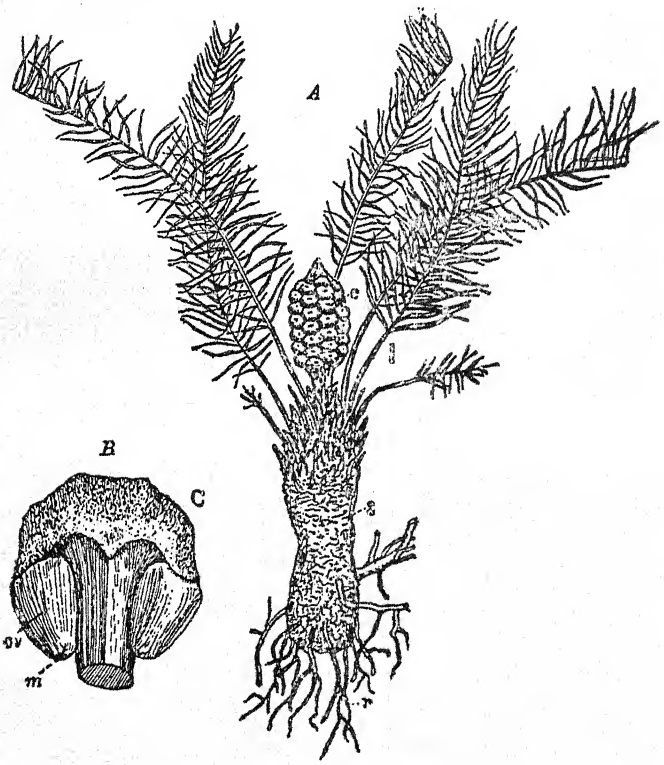



Fig. 212. Zamia (A Cycad).

Fig. 212. A—*Zamia* plant composed of *stem* (s), *rootlets* (r), *leaves* (l) and *female cone* (c). B—A *carpel* (C) bearing *two ovules* (ov) with *micropyle* (m).

## Habitat.

The *Cycads* are tropical or sub-tropical plants and are not widely distributed at the present time.

## Morphological and Microscopic Structure.

The *stem* (Fig. 212 A.s) of a Cycad, *Zamia*, is short and woody and its body is covered with brown scale-leaves and the bases of green compound *leaves*. A number of large, leathery pinnate green leaves occur at the top of the stem (Fig. 212 A.l). Every year or every other year, a cluster of green young leaves are developed at the top of the stem and such leaves are protected by dry brown scale-leaves. The *root* is a tap-root from the sides of which a number of rootlets (Fig. 212 A.r) are developed. Some of the rootlets may become swollen and may come above the surface of the soil. The swollen rootlets are inhabited by an Alga. There are two kinds of sporophylls—*microsporophylls* and *macrosporophylls* which occur on separate plants. The microsporophylls are arranged spirally on an axis to form a *cone*. Each *microsporophyll* (Fig. 213 A.ml) is a tough brown scale bearing on its *lower* surface a number of *microsporangia* or *pollen-sacs* (Fig. 213 A.ps) arranged more or less clearly in groups. The *microspores* or *pollen-grains*, when ripe, are set free by the dehiscence of the *microsporangium* or *pollen-sac*. A number of *macrosporophylls* or *carpels* (Fig. 212 B.C) occur at the apex of the stem and constitute the *female cone* (Fig. 212 A.c). Each *macrosporophyll* or *carpel* (Fig. 212 B.C) is a stout scaly leaf, thickened at its outer end and bearing usually *two* lateral *macrosporangia* or *ovules* (Fig. 212 B.ov), one on each side. Each *ovule* has a *two-layered* covering called the *integument*

(Fig. 213 D.i) which surrounds a large tissue known as the *nucellus* (Fig. 213 D.n) in which the *macrospore* or *embryo-sac* is embedded. The integument does not completely enclose the nucellus but is absent at one point called the *micropyle* (meaning little gate, Fig. 212 B.m & Fig. 213 D.m) through which the pollen-grains enter and come to lie in a small cavity called the *pollen-chamber* (Fig. 213 D.p) which is situated at the top of the nucellus.

## Development and Description of the Gametophyte.

### Female prothallium or Female gametophyte.

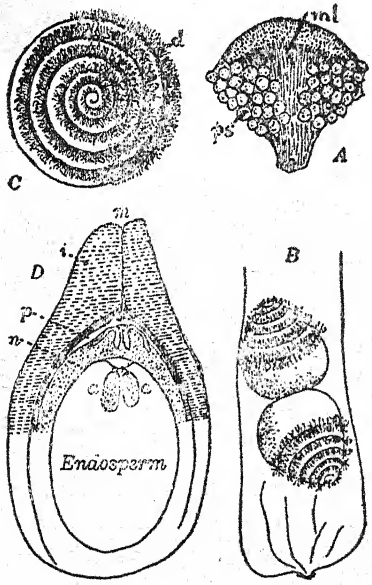



Fig. 213. Microsporophyll, Spermatozoid & Ovule of Zamia (A Cycad).

The nucleus of the *embryo-sac* or *macrospore* divides into many parts and thus many nuclei are produced. A mass of protoplasm gathers round each of these nuclei and subsequently a cell-wall is developed around such a mass of protoplasm; thus a number of cells are produced within the embryo-sac. The cells thus produced within the embryo-sac constitute a tissue known as the *endosperm* (Fig. 213 D.)

Fig. 213. A—*Microsporophyll* (ml) containing *two* groups of *pollen-sacs* (ps). B—*Two* large top-shaped *spermatozoids* at the tip of the pollen-tube ready to be discharged above the archegonia. C—A *spermatozoid* viewed from the end, showing the spiral band which bears the cilia. D—Diagram of a *section of an ovule* after pollination ; *micropyle* (m) ; *integument* (i) ; *pollen- chamber* (p) ; *nucellus* (n) containing developing *pollen-tubes* ; *archegonia* (a) with large *oosphere* embedded in the *endosperm* (female gametophyte).

which corresponds to the vegetative part of the prothallium of a Fern. Several *archegonia* (Fig. 213 D.a) are developed at the micropylar end of the embryo-sac. Each archegonium has a short *neck* composed of four cells. There is a small canal through the cells of the neck. A cell, called *neck-canal-cell,* lies into this canal and the *oosphere* (female cell) lies at the bottom of the neck-canal-cell.

**Male prothallium or Male gametophyte.**

The pollen-grains germinate in the pollen-chamber. At the time of germination, a tube-like structure, known as the *pollen-tube,* is developed from the pollen-grain and the nucleus of the pollen-grain divides into many parts . The *male gametophyte* therefore consists of the protoplasm with several nuclei contained in the pollen-grain and pollen-tube. At the tip of the pollen-tube, a mass of protoplasm gathers round each of some nuclei and subsequently a delicate cell-wall is produced around each of such masses of protoplasm. Thus some cells are produced at the tip of the pollen-tube and one of these cells, termed the *generative cell,* produces two very large *motile spermatozoids* (Fig. 213 B), each with a spiral band or line bearing hundreds of cilia. In the Cycad, *Zamia,* the pollen-tube elongates and comes into contact with the neck of the archegonium

into which it discharges the two spermatozoids together with a drop of a liquid. In other Cycads e.g. *Cycas, Ginkgo* etc., the pollen-tube does not approach the archegonium but by its growth causes the absorption of much of the micropylar portion of the nucellus so that a cavity containing a liquid is formed between the pollen-chamber and the neck of the archegonium ; the spermatozoids are discharged into such a cavity and gradually move down to the archegonium. One of the spermatozoids is finally able to enter the neck of an archegonium and, after dropping down the cilia, unites with the *oosphere ;* the product of union is the *oospore.*

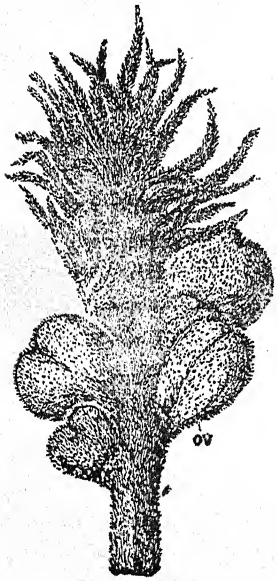



Fig. 214. A carpel of Cycas revoluta.

Fig. 214—A carpel of *Cycas revoluta* which is a pinnately-compound leaf with *five ovules* (ov) occurring in places of *five leaflets* at the lower part.

## Development of the Sporophyte.

After the fertilisation of the oosphere, the ovule becomes the *seed* which possesses two coats, an outer fleshy and an inner hard and woody. Inside the seed, the *embryo* is developed from the cells produced by the division of the oospore. The development of the embryo is said not to take place generally until after the seeds have been shed. The embryo is in touch with a coiled *suspensor* which lies

embedded in the *endosperm.* Around the endosperm, there is a small amount of *perisperm* which is the remaining portion of the nucellar tissue. The embryo possesses *two cotyledons,* a *plumule* and a *radicle.*

——o——

## Sub-division : Gymnosperms or Gymnospermae.

### Order : Coniferae.

### Type : PINUS.

**Habitat.**

The *Coniferæ* are mostly inhabitants of temperate regions and occur even in places which are nearest to the polar regions. Within the tropics, they are mostly confined to mountains.

## Description of the Sporophyte.

### Morphological Structure.

The plant generally grows into a large tree with a strong woody stem, except at high altitudes, where it becomes stunted. The stem is covered with a rough scaly bark. The plant has a primary root which, if the soil is of sufficient depth, will penetrate down and form a well-marked *tap-root,* giving out strong secondary roots, but if the soil is shallow, will soon become arrested and the secondary roots will spread out near or on the surface of the ground. The main branches of the stem come off in apparent whorls, but the secondary branches tend to be formed mainly from the sides of the stem, so that they come to lie more or less in a horizontal plane. Besides the *long branches* which end in a

bud and have *indefinite growth*, there are other branches of *limited growth* which cover all the younger parts of the plant and are also known as the *dwarf shoots* or *bifoliar spurs*. The dwarf shoots are covered at the bottom with *scale-leaves* and bear at the apex *a pair* of long needle-shaped *green-leaves* (Fig. 215.A). The *sporophylls* are collected together into *flowers* or *cones* which are *unisexual*, both male and female flowers occurring on the same plant. The **female flower** (Fig. 215.A & D) is developed in the place of a *branch of unlimited growth* of the current year and consists of an *axis* bearing a large number of spirally arranged scale-leaves which are the *macrosporophylls*, *bract-scales* or *carpellary scales* (Fig. 216.CARISC). On the *upper surface* of each bract-scale, there is another scale-leaf known as the *ovuliferous scale* (Fig. 216.ov.sc) upon which *two macrosporangia* or *ovules* (Fig. 216.ov & 215 B.o) are developed. The **male flower** (Fig. 217 A, B & Fig. 218) is developed in the place of a *dwarf-shoot* of the current year and consists of an *axis* bearing a large number of spirally-arranged scale-leaves which are the *microsporophylls* or *staminal leaves*. On the *under surface* of each microsporophyll or staminal leaf, *two microsporangia* or *pollen-sacs* (Fig. 217 B & 218.P.S) are developed. Each *microsporangium* or *pollen-sac* contains a large number of *microspores* or *pollen-grains* (Fig. 217 B).

## Microscopic Structure.

### Stem.

The *stem of Pinus* closely resembles the *stem of a Dicotyledon*. In a *very young stem*, the following structures can be successively seen—(1) The *Epidermis* consisting

of one layer of cells, the outer walls of which are strongly cuticularised. (2) The *Cortex* (Left Fig. 220.COR) consisting of several layers of parenchymatous cells ; in the deeper layers of cortex, there are some *resin-passages* (Left Fig. 220.RD). (3) The *Endodermis & Pericycle* are not well-differentiated. (4) The *Phlœm* (Left Fig. 220.PH & Fig. 219 B.Bast) consisting of *parenchymatous cells* and *sieve-tubes without companion-cells ;* there are numerous sieve-plates on the radial walls of the sieve-tubes. (5) The *Cambium* (Left Fig. 220.CB & Fig. 219 B.Cam) consisting of a few layers of brick-shaped parenchymatous cells. (6) The *Xylem* (Left Fig. 220.XY & Fig. 219 B.Wood) consisting of *tracheids with bordered-pits ;* there are small *resin-passages* (Left Fig. 220.RD) in the protoxylem and secondary xylem. (7) The *Pith* (Left Fig. 220.PI & Fig. 219 B.Pith) consisting of thin-walled parenchymatous cells. (8) The *medullary rays* (Left Fig. 220.M.R & Fig. 219 B.m) are plates of cells which extend from xylem to phlœm ; the medullary rays in the secondary xylem consist of cells with strongly *lignified walls* and *closed pits on their walls.* (Note : **Secondary growth** takes place in exactly the same way as in the Dicotyledons. After secondary growth, the *Epidermis* ruptures and is cast away and hence the *structure of the stem* consists of (1) *Cork,* (2) *Cork-cambium,* (3) *Cortex,* formed of secondary and primary cortex, (4) *Pericycle,* (5) *Endodermis,* (6) *Phlœm,* (7) *Cambium,* (8) *Xylem,* (9) small amount of *Pith,* and (10) *Medullary rays.* (See Figs. 219 B & 220.Left).

## Root.

The *root of Pinus* also closely resembles the *root of a*

*Dicotyledon.* In a *very young root,* the following structures can be successively seen—(1) The *Piliferous layer ;* (2) The *Cortex ;* (3) The *Endodermis,* one-layered ; (4) The *Pericycle,* many-layered ; (5) Y-shaped *Xylem bundles* with a *resin-passage* (Right Fig. 220.R.D) at the apex of each arm of Y (Right Fig. 220.XY) ; the xylem bundles alternate with the same number of *phlœm bundles.* (6) The *Medullary rays* (Right Fig. 220. MT) consist of cells with strongly lignified walls and *closed pits* on their walls. (Note : **Secondary growth** takes place as in the Dicotyledons. *Cork* is developed in the *pericycle,* so that after the formation of cork, the *endodermis, cortex* and *piliferous layer* are cast away. The following structures can therefore be seen after secondary growth—(1) *Cork ;* (2) *Cork-cambium ;* (3) *Secondary Cortex ;* (4) *Phlœm ;* (5) *Cambium ;* (6) *Xylem ;* (7) *Medullary rays* which cross xylem and phlœm radially. (See Right Fig. 220).

## Leaf.

The upper surface of the leaf of Pinus is more or less flat and the lower surface much curved. The following structures can be seen in the leaf—(1) The *Epidermis* (Fig. 221.e) with its very strongly cuticularised walls. The *guard cells* (Fig. 221.st) of the *stomata,* developed on all sides of the leaf, are *much below the level of the surface.* (2) Layers of *sclerenchymatous fibres* (Fig. 221.r) occur below the epidermis except where stomata occur. (3) Several layers of *chlorophyll-containing parenchymatous cells,* of which the inner especially show curious infoldings of the walls ; the infoldings probably increase the assimilating surface. There are a few *resin-passages* (Fig. 221.d) among

these parenchymatous cells (Fig. 221.Green Tissue). (4) The *endodermis* (Fig. 221.bs). (5) The *pericycle* (Fig. 221.t) is very peculiar and consists of two kinds of tissues :—(*a*) *parenchymatous tissue* with abundant protein and starchy cell contents and (*b*) *tracheidal tissue* with a number of small *bordered pits*. The parenchymatous tissue appears to make up for the *small amount of phlœm*, for through this parenchymatous tissue the protein formed in the green cells pass into the vascular bundle. The tracheidal tissue helps to compensate for the *small amount of xylem* and to pass solution of food material to the chlorophyll-containing assimilating tissue. These two forms of tissue (*e.g.* parenchymatous & tracheidal) constitute the **transfusion tissue,** which is very characteristic of the leaves of Gymnosperms. The pericycle consists of some *sclerenchymatous fibres* which completely surround (6) *two vascular bundles*, each of which is composed of *Xylem* (Fig. 221.Wood), facing towards the upper surface of the leaf, *cambium* and *phlœm* (Fig. 221.Bast). The *presence of cambium in the vascular bundle* is also peculiar to the leaves of Gymnosperms. (7) The *Medullary rays* in the vascular bundles are well marked.

## Development and Description of the Gametophyte.

### Female prothallium or Female gametophyte.

The *ovule* consists of a mass of parenchymatous tissue, called the *nucellus* (Right Fig. 216.NU & Fig. 222 A.n), surrounded by a single covering called the *integument* (Right Fig. 216.INT & Fig. 222 A.i) which is absent at one point called the *micropyle* (Right Fig. 216. MI & Fig.

222 A.m). At the base of the nucellus, there is a large cell called the *embryo-sac* or *macrospore* (Left Fig. 216. EM.SC) which divides repeatedly and thus a tissue, called the *endosperm* (Right Fig. 216.PRO & Fig. 222 A.Endosperm), is formed. The endosperm corresponds to the **female prothallium.** At the micropylar end of the endosperm, *two* or *three* archegonia (Right Fig. 216 & Fig. 222A.ar) are developed. Each archegonium consists of a short *neck* formed of *four* cells and a very large cell known as the *oosphere* which is embedded in the endosperm and surrounded by a well-defined layer of cells, called the *jacket cells*, of the endosperm (Fig. 222.D). There is a small canal through the cells of the neck ; this canal contains a cell called the *ventral-canal-cell.*

**Male prothallium or Male gametophyte.**

The flowers of Pinus are *wind-pollinated.* Each *pollen-grain* (Fig. 217.F & Left Fig. 218.PG) has two balloon-like expansions by means of which it floats in the air and may happen to fall near an ovule of a female flower where it is caught by the *mucilage* which is, by this time, excreted from the ovule. The mucilage gradually dries up and drags down the pollen-grains which are ultimately conveyed to a small cavity, known as the *pollen-chamber* (Fig. 222 A.pc), situated above the nucellus. Even before leaving the anther, the pollen-grain begins to divide and the divisions are completed while lying near the ovule. At first two very minute cells, called the *prothallial cells* (Fig. 222.B.p), are cut off from the pollen-grain ; the remaining portion of the pollen-grain then divides into a small *antheridial cell* and a large *vegetative cell* which elongates into a

tube-like structure known as the *pollen-tube* (Fig. 222.B). The pollen-tube develops and forces its way through the cells of the nucellus and reaches one of the archegonia (Fig. 222.A). During this time, the antheridial cell divides into two cells, the *stalk cell* and the *generative cell*. The prothallial cells then collapse and the cell-walls of the vegetative cell, stalk cell and generative cell dissolve and the protoplasmic contents and nuclei of these cells then pass down to the apex of the pollen-tube where the generative cell, consisting of a mass of protoplasm and a nucleus, divides into two cells known as the *male gametes* (Fig. 222 C.S) ; the nuclei of the other cells then disappear. The **male prothallium** is therefore represented by the two prothallial cells, vegetative cell, stalk cell and generative cell (Fig. 222 B.p.g.t).

## Fertilisation.

*Fertilisation* takes place *about a year after pollination.* The process of fertilisation consists in one of the male gametes uniting with a female gamete (oosphere) ; the product of union is known as the *oospore.*

## Development of the Sporophyte.

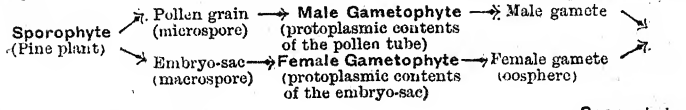
In the female prothallium (*e.g.* endosperm), the oosphere of more than one archegonium may be fertilised. The oospore of each archegonium repeatedly divides and produces *four suspensors* (Fig. 215 F.s) and *four embryos ;* hence in the unripe seed, we find a *number of very young embryos.* But as development proceeds, all the embryos except *one* become abortive so that in the ripe seed, there is *only one embryo.* The embryo consists of a whorl of about *eight cotyledons* (Fig. 215 F.c), a *radicle* and a *plumule* and is

embedded in the unused part of the endosperm (Fig. 215 F.en) which has encroached on the tissue of the nucellus (Fig. 215 F.n) to such an extent that only a very thin layer, the *perisperm*, of the nucellus remains. The endosperm and perisperm contain food materials for the developing embryo. After fertilisation, the *ovule* becomes the **seed**; the *integument* of the ovule becomes the *testa* (Fig. 215 F.t) and the micropyle of the ovule remains as the *micropyle* (Fig. 215 F.m) of the seed. In the third year, when the scales of the woody cone open out (Fig. 215.D), the seeds are set free as winged bodies. The *wing* (Fig. 215 C.w) of the seed is derived from the upper surface of the placenta. At the time of germination, the radicle at first passes down into the ground and becomes the tap-root. The testa then falls off. The cotyledons of Pinus may become green while lying within the testa and then open out to form a whorl of green leaves. The plumule grows out between the cotyledons and becomes the shoot. In the first year, the shoot produces only green needle-shaped leaves but not scale-leaves and dwarf-shoots.

## Alternation of Generations in Pinus sylvestris.

In the life history of *Pinus sylvestris*, the *plant itself* represents the **sporophyte** generation as it bears *spores* (*e.g.* microspores or pollen-grains and macrospores or embryo-sacs). The pollen-grain gives rise, on germination, to the *male prothallium*; the embryo-sac gives rise to the *female prothallium*. The *male prothallium* and *female prothallium* represent the **gametophyte** generation. Since these two *generations* (sporophyte and gametophyte) succeed one another regularly, the life history of the plant is said to exhibit regular "**alternation of generations.**"

The life history of *Pinus sylvestris* may be expressed by the following formula—



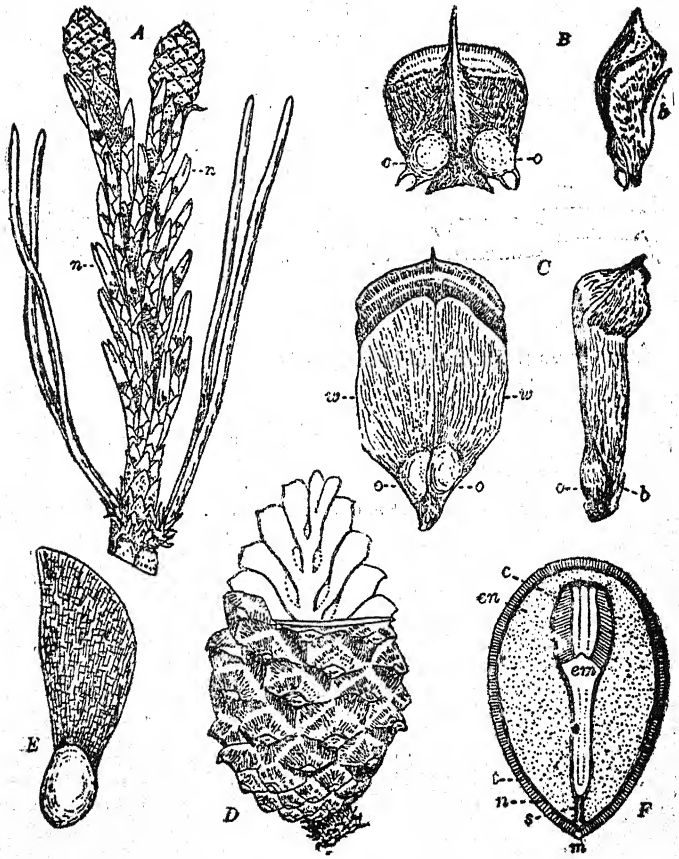




Fig. 215. Female flower or *cone* of Pinus sylvestris.

Fig. 215. A—Two *female flowers* and a number of *bifoliar spurs* (n) at the bottom ; at the base, there are *two large bifoliar spurs* with *scale-leaves* at the bottom. B—Inner and side view of a *macrosporophyll or bract-scale* with two *ovules* (o) and *bract* (b). C—Inner and side view of a *macrosporophyll* from a two-year old female cone as shown in D ; *bract* (b), fertilised *ovules* (o) rapidly maturing into *seeds* with *wings* (w). D—A two-year old *female cone* or *flower*. E—A mature *winged seed*. F—*Section of mature seed*, showing *hard seed-coat* or *testa* (t) developed from the integument of the ovule, a *membranous seed-coat* which is the remains of the nucellus (n), *endosperm* (en) or tissue of the female gametophyte, *embryo* (em) with a group of *cotyledons* (c), *suspensor* (s) and *micropyle* (m).

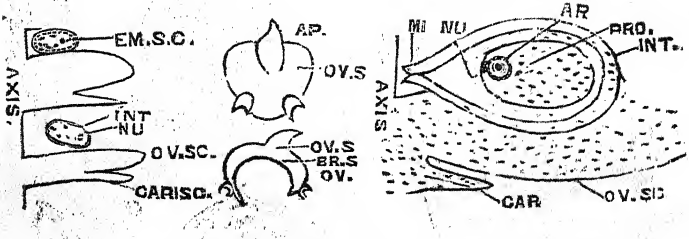



Fig. 216. Section of *female flower* or *cone* of Pinus sylvestris.

*Left figure* (Longitudinal section of female flower).

*Axis* bearing *ovuliferous scales* (ov.sc) at the bottom of which there is a *bract-scale* (CARISC) ; the ovuliferous scale bears *ovule* with *integument* (INT), enclosing a *nucellus* (NU) in which lies an *embryo-sac* (EM.SC).

*Middle figure* (Carpels of female flower).

At the *top*, *upper view* of a carpel or *bract-scale* which is hidden from view by the vigorous development of the *ovuliferous scale* (ov.s) bearing *two ovules* at the base ; the *apical portion* (AP) of the ovuliferous scale has been prolonged. At the *bottom*, *under view* of a carpel or *bract-scale* (BR.S) upon which lies the *ovuliferous scale* (ov.s) bearing *two ovules* (ov).

*Right figure* (Magnified view of section of portion of a female flower).

*Axis* of the female flower bearing *bract-scale* (CAR) upon which lies the *ovuliferous scale* (ov.sc) bearing on the *upper surface* an *ovule* formed of an *integument* (INT) which is absent at a point known as the *micropyle* (MI) ; the integument encloses a tissue known as the *nucellus* (NU) within which lies the *female prothallium* or *endosperm* (PRO) ; the female prothallium bears *archegonium* (AR).

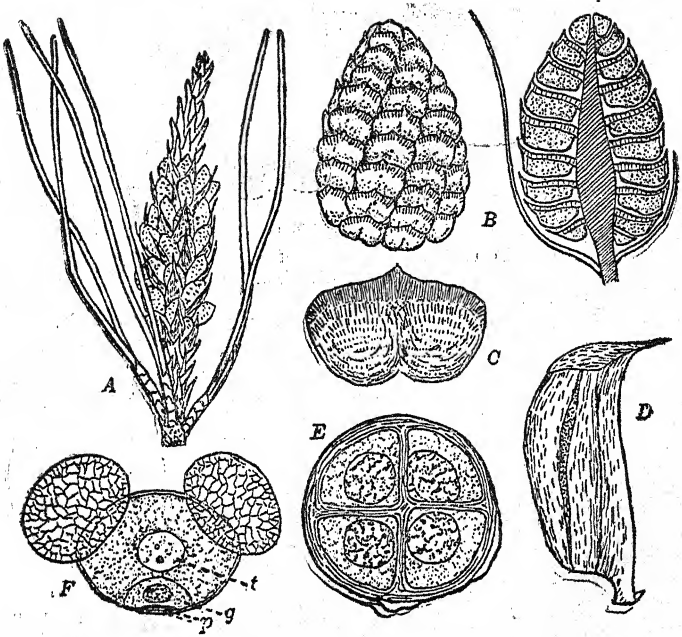



Fig. 217. *Male flower* or *cone* of Pinus sylvestris.

A—A *male flower* or *cone* at the base of which there are *three bifoliar spurs* having *scale-leaves* at the base. B—*Left figure* is the *surface view* of a *male cone* and the *Right figure* is a sectional view of a *male cone* showing the *anthers* developed on the *under surface* of the *staminal leaves* and containing *pollen-grains*. C—End view of a *staminal leaf*. D—Side view of a *staminal leaf*. E—*Pollen-mother-cell* developing *four pollen-grains*. F—A *pollen-grain* showing the *two bladder-like expansions, prothallial cell* (p), *generative cell* (g) and the *vegetative cell* (t).

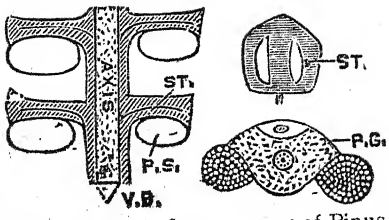



Fig. 218. Section of *male flower* or *cone* of Pinus sylvestris.

*Left figure*—(Longitudinal section of male flower).
*Axis* of the flower bearing *staminal leaf* (ST) which bears *pollen-sac* (P.S).
*Right figure*—A *staminal leaf* (ST) and a *pollen-grain* (PG).

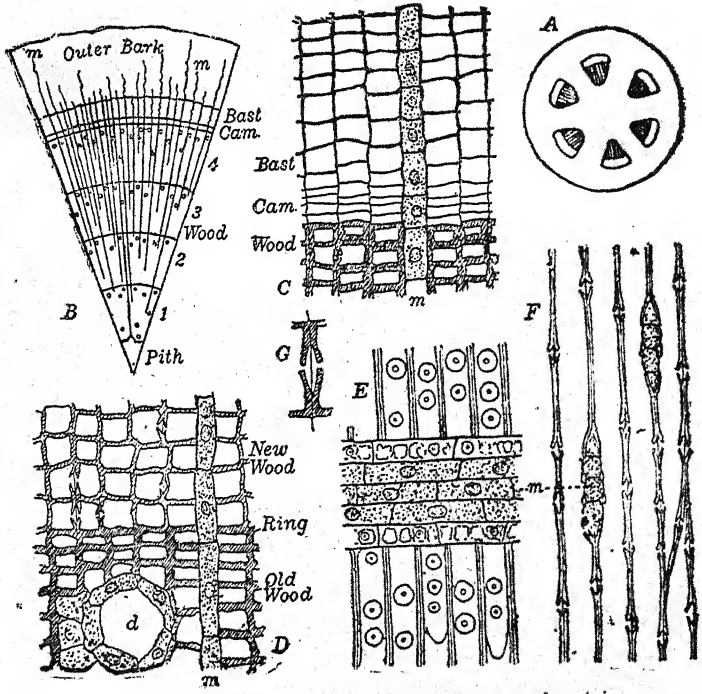



Fig. 219. Section of the *stem* of Pinus sylvestris.

Fig. 219. A—Section of the *stem before secondary growth*. B—Section of a four-year old stem. C—Cross section of the *region of cambium* (Cam) with adjacent *xylem* (wood), *phloem* (bast) and a *medullary ray* (m). D—Cross section of *xylem* (wood) at an *annual ring* composed of *new wood* and *old wood* with a *medullary ray* (m) passing through the wood and a *resin-passage* (d) occurring in the wood. E—Radial section of xylem showing the circular *bordered pits on tracheids* and *medullary rays* (m). F—Longitudinal section of xylem showing *medullary rays* (m) and *bordered pits* as shown in (G).

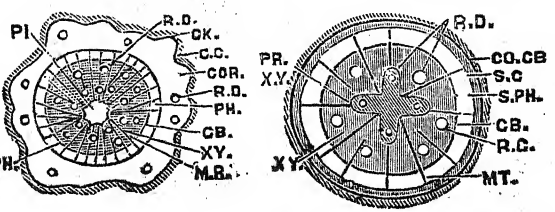



Fig. 220. Section of *stem and root* of Pinus sylvestris.

*Left figure* (Stem after secondary growth).

*Cork* (CK) ; *Cork-cambium* (CC) ; *Cortex* (COR) containing *resin-passages* (RD) ; *Phloem* (PH) ; *Cambium* (CB) ; *Xylem* (XY) containing *medullary rays* (M.R) and *resin-passages* (RD) ; *Pith* (PI).

*Right figure* (Root after secondary growth).

*Cork-cambium* (CO.CB) with *cork* outside it ; *secondary cortex* (S.C) ; *secondary phloem* (S.PH) ; *cambium* (CB) ; *secondary xylem* (XY) containing *resin-passages* (R.D) ; *medullary rays* (MT) ; *protoxylem* (PR.XY) containing a *resin-passage* at the apex.

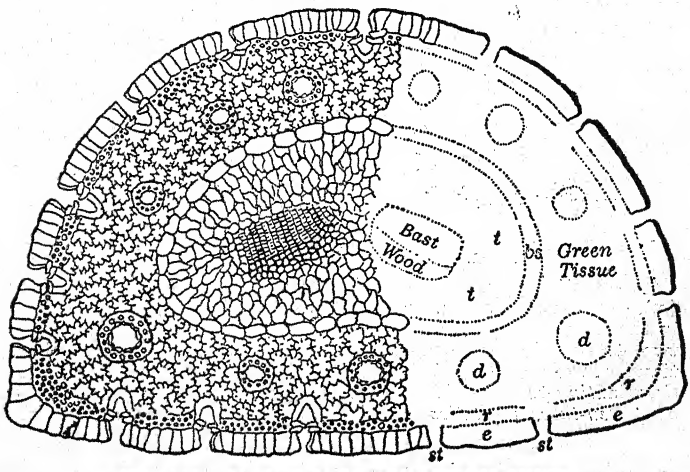



Fig. 221. Section of *Leaf of Pinus sylvestris*

Fig. 221. *Epidermis* (e) containing *stomata* (st) ; patches of *Sclerenchyma* (r) below the epidermis ; *Green parenchymatous tissue* (Green Tissue) with peculiar infoldings of their walls and containing *resin-passages* (d) ; *Endodermis* (bs) ; *Pericycle* (t) ; *Xylem* (Wood) ; *layer of cambium*, *Phloem* (Bast) and radiating *medullary rays* across the xylem and phloem.

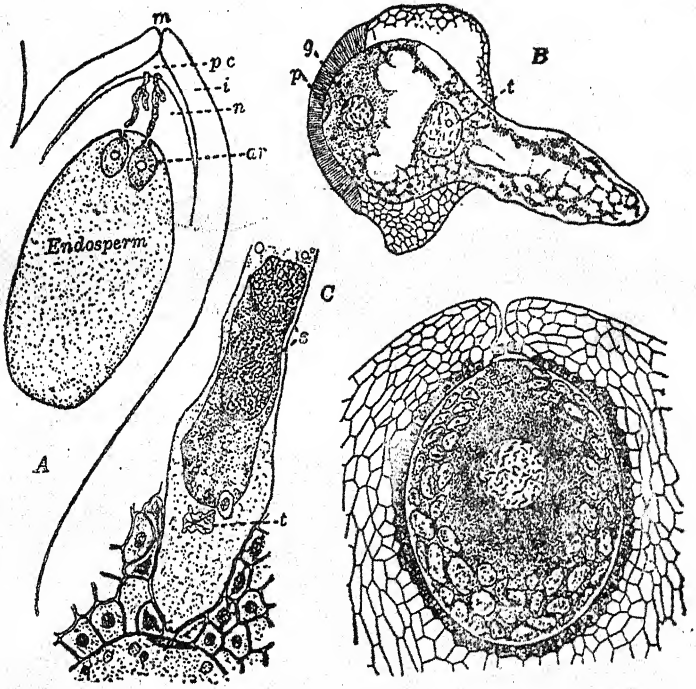



Fig. 222. *Gametophytes of Pinus sylvestris.*

A—Section of *a year-old ovule* showing *integument* (i), *micropyle* (m), *pollen-chamber* (pc), *nucellus* (n), *two archegonia* (ar) embedded in the tissue of the *endosperm* (female prothallus or gametophyte), two *pollen-tubes* (male gametophytes) growing down through the tissue of the nucellus (n) towards the two archegonia (ar). (B)—*Germinating pollen grain* showing *young male gametophyte* consisting of *pollen-tube*, *vegetative nucleus* (t), *generative nucleus* (g) and

*prothallial cell* (p). C—Magnified view of the *tip of pollen-tube* applied to the *oosphere* and possessing *vegetative nucleus* (t) and *two male gametes* (s). D—Magnified view of a *mature archegonium* embedded in the tissue of the endosperm and showing the *large oosphere* surrounded by a *jacket of cells* rich in protoplasm ; two *neck-cells* of the archegonium are shown just above the oosphere.

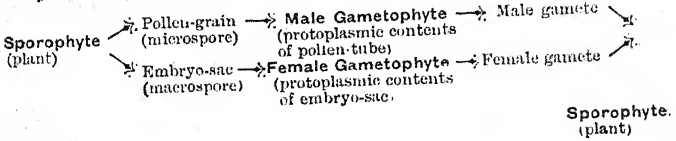
**38.** Indicate clearly the phenomenon of "Alternation of Generations" in Monocotyledons and Dicotyledons and state the principal points of difference between the (A) **Algae and Fungi (C. U. 1913, 1922),** (B) Mosses and Ferns, (C) **Ferns, Monocotyledons and Dicotyledons (C. U. 1912),** and (D) **Monocotyledons and Dicotyledons (C. U. 1919).**

**"Alternation of Generations" in Monocotyledons and Dicotyledons.**

In the life history of a Monocotyledon or Dicotyledon, we notice two stages or generations—an *asexual* and a *sexual.* The *asexual generation* or **Sporophyte** is represented by the leafy plant because it bears asexual reproductive structures known as the *spores* (*e.g.* microspore or pollen-grain & macrospore or embryo-sac). The microspore or pollen-grain germinates and produces the pollen-tube which contains two male gametes, nucleus of the vegetative cell and some protoplasmic matter. *The pollen-tube with its contents represents the* **male gametophyte.** The macrospore or embryo-sac germinates and produces the egg-apparatus, three antipodal cells and two polar nuclei. *The mature macrospore or embryo-sac with its egg-apparatus, antipodal cells and polar nuclei represents the* **female gametophyte.** The female gamete (oosphere) is fertilised by one of the male gametes and the structure thus produced is the *oospore* which divides and gives rise again to the plant which is the **sporophyte.** Since these two generations (*sporo-*

*phyte* & *gametophyte*) of the plant succeed one another regularly, the life history of a Monocotyledon or Dicotyledon is said to exhibit regular "*alternation of generations.*"

The life history of a Monocotyledon or Dicotyledon may be expressed by the following formula—




——o——

**(*A*) Difference between the Algae and Fungi. (C. U. 1913, 1922).**

(*a*) *Structure and differentiation of body.*

(1) The vegetative body of the Fungi is unicellular or coenocytic; the vegetative body of the Algae is unicellular, coenocytic or multicellular. (2) The body of Fungi may at most be differentiated into root and shoot and the shoot is never differentiated into stem and leaf. The body of the Algae may even be differentiated into root, stem and leaf.

(*b*) *Mode of Nutrition.*

The Algae possess in their bodies chloroplastids which, in the presence of light, can build up complex carbon-containing compounds; the Fungi do not possess chloroplastids in their bodies and hence they are dependent for their food on living plants and animals when they are known as *parasites*, or on decaying organic matter when they are known as *saprophytes*.

(c) *Structure and differentiation of sexual organs.*

(1) In the Algae, the sexual cells (gametes) may or may not be ciliated ; in the Fungi, the sexual cells are never ciliated. (2) In the Algae, the sexual organs are sometimes *unicellular* but generally *multicellular* and complicated in structure ; in the Fungi, the sexual organs are sometimes *multicellular* but generally *unicellular* or *coenocytic* in structure.

(d) *Different stages in the life history.*

The life history of the Fungi generally exhibits *poly morphism*, that is, several distinct phases in the course of their life ; polymorphism is almost absent from the life history of the Algae.

(*B*) **Difference between the Mosses and Ferns.**

(a) *Structure of the gametophyte.*

(1) The gametophyte of the Moss is differentiated into stem, leaf and root-like structures called rhizoids ; the gametophyte of the Fern is a green, leaf-like, heart-shaped structure which is not differentiated into stem and leaf but rhizoids are developed from it. (2) The stem of the Moss is differentiated into tissues which may be comparable to the *epidermis* and *cortex* of the *sporophyte of higher plants ;* there is no such differentiation of tissues in the prothallus of the Fern. (3) The sexual organs of the Moss are surrounded by delicate leaves and hair-like structures called the paraphyses ; in the Fern, the sexual organs are not surrounded by delicate leaves and paraphyses. In the Moss, the female sexual organ, at the time of maturity, throws out of its neck a mucilaginous substance containing *cane-sugar* ; in the Fern, the mucilaginous substance contains *malic acid*.

(*b*) *Structure of the Sporophyte.*

(1) The Sporophyte of the Moss is at first differentiated into a root-like structure called the foot and a shoot which is differentiated only into a stalk bearing, at the top, a sporangium known as the capsule ; through the foot, the sporophyte derives nourishment from the gametophyte. The sporophyte of the Fern is highly differentiated into root and shoot comprising stem and leaf. (2) The stoma of the sporophyte (*e.g.* capsule) of the Moss has *one* guard-cell ; in the Fern, there are *two* guard-cells. (3) The microscopic structure of the sporophyte of the Moss shows that the body of the sporophyte consists mainly of parenchymatous cells ; the body of the sporophyte of the Fern is highly differentiated into parenchymatous tissue, vascular tissue and, in many cases, sclerenchymatous tissue. (4) In the Moss, the sporangium (*e.g.* capsule) possesses structures known as the peristome, operculum, calyptra and columella; in the Fern, these structures are absent. The *annulus* is present in the sporangium of both Moss and Fern and it is directly or indirectly concerned with the dehiscence of the sporangium. (5) Each spore of the Moss, on germination, does not directly give rise to the gametophyte but a structure known as the protonema is at first produced and on the protonema the gametophyte subsequently develops as a bud ; the spore of the Fern directly gives rise to the gametophyte and no structure like the protonema is at all produced.

(*C*) **Difference between the Ferns, Monocotyledons and Dicotyledons. (C. U. 1912).**

(*a*) *Mode of arrangement and the composition of vascular bundles.*

(1) The stem of Fern is commonly polystelic ; in the Monocotyledons & Dicotyledons, it is monostelic. In the stem of a Fern, the vascular bundles are scattered, like the vascular bundles of Monocotyledons, over the ground-tissue which is thus undifferentiated into cortex, pericycle, pith and medullary rays ; in the stem of a Dicotyledon, the vascular bundles are generally arranged in the form of a circle and hence the ground-tissue is differentiated into cortex, pericycle, pith and medullary rays. (2) The vascular bundle of the stem and that of the root of a Fern consist of phloem entirely surrounding the xylem ; in Monocotyledons & Dicotyledons, the xylem and phloem lie side by side. (3) *Fascicular cambium* and *cork-cambium* are absent in Fern and generally in Monocotyledons ; in Dicotyledons, they are present. (4) The *phloem* of a Fern consists of sieve-tubes *without companion-cells* and parenchyma and the *xylem* consists generally of scalariform tracheids and parenchyma ; the phloem of a Monocotyledon and Dicotyledon consists generally of sieve-tubes *with companion-cells*, parenchyma and sclerenchyma and the xylem consists generally of vessels, parenchyma and sclerenchyma, though tracheids may also be present.

(*b*) *Sporophylls & Sexual organs.*

(1) The sporophylls of a Fern are generally similar to the foliage-leaves and are not grouped together into flowers ; in a Monocotyledon & Dicotyledon, the structures of the sporophylls are generally quite different from those of the foliage-leaves and the sporophylls are aggregated into flowers. (2) In a Fern, the spores (macrospores and microspores) are set free from the sporangia ; in a Mono-

cotyledon & Dicotyledon, the macrospore is never set free from the macrosporangium and hence the germination of the macrospore and the fertilisation of the female gamete take place within the macrosporangium which, after the fertilisation of the female gamete, is known as the seed, a body not formed in a Fern as the macrospore of a Fern is always set free from the macrosporangium. (3) The sporangia of Ferns occur in *sori* which are covered by a structure called the *indusium;* the sporangia of Monocotyledons & Dicotyledons do not occur in sori and they are not covered by indusium. (4) The macrosporangia of a Fern lie exposed on the macrosporophyll ; in a Monocotyledon & Dicotyledon, the macrosporangium lies enclosed within the macrosporophyll. (5) In a Fern, the male and female sexual organs are highly differentiated ; in a Monocotyledon & Dicotyledon, the sexual organs are represented by a few cells. (6) In a Fern, the male gamete possesses many cilia by the movement of which it approaches the female gamete ; in a Monocotyledon & Dicotyledon, the male gamete possesses no cilia and it is conveyed to the female gamete through a structure known as the pollen-tube developed from the microspore after the microspore falls to the stigma.

*Structure of the embryo.*

In a Monocotyledon & Dicotyledon, the body of the embryo is usually differentiated into one cotyledon in Monocotyledons and two cotyledons in Dicotyledons, a stem and a root ; a structure called the suspensor remains attached to the embryo. In a Fern, the body of the embryo is differentiated into one cotyledon, a stem and a root ;

no structure like the suspensor of a Monocotyledon & Dicotyledon is found attached to the embryo but a structure called the foot is developed from the embryo and the function of the foot agrees to a great extent with that of the suspensor.

(*D*) **Difference between the Monocotyledons and Dicotyledons (C. U. 1919).**

(*a*) *Seed and its germination.*

(1) The seeds of Monocotyledons have only one cotyledon and endosperm is generally present in them ; the seeds of Dicotyledons, with some exceptions, have two cotyledons and endosperm is generally absent from them. (2) At the time of germination, the plumule of Monocotyledonous seed is pushed out of the seed by the elongation of the basal portion of the cotyledon, while in Dicotyledonous seed, this work is done by the hypocotyl. (3) In the development of the embryo, the cotyledon is terminal and the plumule lateral in a Monocotyledon ; in a Dicotyledon, the plumule is terminal and the cotyledon lateral.

(*b*) *Root.*

(1) The primary root in Monocotyledons seldom persists and adventitious roots soon appear in its place, while Dicotyledons generally possess well-marked primary root. (2) The number of vascular bundles in Monocotyledonous root is much more than that in Dicotyledonous root. (3) In Dicotyledonous root, there is secondary growth in thickness ; in Monocotyledonous root (with few exceptions) there is no secondary growth in thickness.

(*c*) *Stem.*

(1) The stem of a Monocotyledon is generally under-

ground forming bulbs, corms etc. and even when the stem is aerial, it is but slightly branched ; the stem of a Dicotyledon is generally aerial and much branched. (2) In a Monocotyledon, the vascular bundles of the stem, in transverse section, are scattered over the ground-tissue and except in a few cases, there is no secondary growth in thickness of the stem ; in a Dicotyledon, the vascular bundles are situated in the form of a circle in transverse section and there is secondary growth in thickness of the stem.

(*d*) *Foliage-leaves.*

The foliage-leaves of Monocotyledons are generally simple, exstipulate and at the base of the lamina there is generally a well-developed sheath embracing the stem or branch ; the venation is generally parallel. The foliage-leaves of Dicotyledons are simple, compound or bicompound, often stipulate and the leaf-bases are seldom sheathing ; the venation is generally reticulated.

(*e*) *Floral structure.*

The floral structure of a Monocotyledon can generally be represented by the formula $K_3\ C_3\ A_3+3\ G_3$ ; while in a Dicotyledon, it can be represented by the formula Kn Cn An Gn, where n is 4 or 5.

### Inter. Questions from 1909-22.

1. In what respects does a Fern differ from a Dicotyledon ? (1912).

2. What is the essential difference between the Fungi and Algæ ? (1913).

3. How do Monocotyledons differ from Dicotyledons ? (C.U. 1919).

4. Explain briefly the difference between Algæ and Fungi. Give examples to illustrate your answer.

**39.** Write short notes on the following terms :—

ACHLAMYDEOUS : a flower without calyx and corolla.

ACTINOMORPHIC : a flower which can be divided into similar halves by more than two planes passing through its axis.

ADHESION : union between the parts of different whorls of a flower *e.g.* when the stamens are attached to the petals.

ALBUMINOUS SEED : a seed with some albumen remaining until its germination.

**Aleurone grains** (C. U. 1910) : grains found in the endosperm of many seeds. Each grain generally consists of two portions—one, known as the *globoid*, consists only of mineral matters, and the other, known as the *crystalloid*, consists only of proteins. Sometimes the crystalloid may occur without the globoid.

**Amplexicaul** (C. U. 1921) : a leaf with a sheathing base completely encircling the stem or branch.

**Anatropous ovule** (C. U. 1916) : an ovule with the apex drooping down in such a way that the micropyle and hilum are situated close to each other and the chalaza lies farther from the micropyle.

APOGAMY : if in the life-cycle of a plant, the sexual organs are not formed so that the sporophyte is developed as a bud on the prothallus or from the unfertilised oosphere ; this condition is known as *apogamy*.

APOSPORY : if in the life-cycle of a plant, the spores are not formed so that the prothallia are developed directly from the sporangia or from the placentas or from any portion of the body of the plant ; this condition is known as *apospory*.

**Aril** (C. U. 1920) : a third seed-coat.

**Bordered pits** (C. U. 1917) : in many xylem-vessels and tracheids, a circular area of the original wall is left unthickened. As the thickening is laid down on the surrounding wall, each layer projects a little farther than the last over this area. In surface view, the bordered pit has the appearance of two concentric circles.

BRACT : a leaf borne on the peduncle.

BRACTEOLE : a leaf borne on the pedicel.

**Capitulum** (C. U. 1920, 1921) : a racemose inflorescence with a conical, disc-shaped or hollowed out main axis bearing stalkless flowers.

**Cladode** (or Phylloclade) C. U. 1916 : green succulent stem or branch with leaves reduced to spines or scales bearing flowers in the axils.

CALLUS : a layer of peculiar substance lying on both the sides of the sieve-plate of a sieve-tube. The term *callus* is also applied to a tissue which is formed from a meristematic tissue bordering on a wound.

CAMBIUM : a layer of meristematic tissue between masses of permanent tissue. Owing to the activity of cambium, there is secondary growth in thickness in a member of a plant.

**Capsule** (C. U. 1910) : sporangium of Moss. The term *capsule* is also applied to a superior, one or more-celled, many-seeded, dry, dehiscent simple fruit.

CARCERULE : a superior schizocarpic fruit formed from a bicarpellary ovary which is converted into four nutlets by false partitions.

**Caudex** or Stipe (C. U. 1916) : an unbranched stem bearing a cluster of leaves at the top, as in Palms.

**Cohesion** (C. U. 1910) : union between the members of a whorl of a flower *e.g.* gamopetalous corolla.

**Connective** (C. U. 1910) : : a tissue between the two lobes of an anther.

CORDATE (heart-shaped) : if the lamina of a leaf is pointed towards the apex and broad and notched at the base.

**Corm** (C. U. 1916) : a swollen underground stem the surface of which is more or less completely covered with scale-leaves. One or more buds are developed in the axils of scale-leaves. Adventitious roots arise from the base of the bud and also from the base of the stem. Later in the

year, when flowering is over, a new corm is formed by the accumulation of food materials in the basal portion of the flowering shoot. In this way, the corms of two or three years adhere together.

**Corymb** (C. U. 1913) : a racemose inflorescence with the stalks of flowers of unequal lengths so that the flowers lie almost in a horizontal plane.

CULM : a jointed stem.

CUNEATE : a lamina which is gradually pointed towards the base and broad towards an abruptly pointed apex.

**Decussate** (C. U. 1915) : if the successive pairs of opposite leaves are at right angles to each other.

**Deliquescent** (C. U. 1917) : stem with cymose branching.

DERMATOGEN : well defined outermost layer of cells at the growing-point.

DIADELPHOUS : two bundles of stamens formed by the union of filaments.

DICHASIUM : a cymose inflorescence with two branches arising below the terminal flower.

DICHLAMYDEOUS : a flower with both calyx and corolla.

**Dichotomous** (C. U. 1915) : branching by two buds formed by the splitting of the terminal bud.

DICLINOUS (or unisexual) : a flower with either androecium or gynaecium.

**Didynamous** (C. U. 1919) : four stamens, two long and two short.

DIMORPHISM : occurrence of two kinds of flowers on different plants of the same species ,one kind of flower possessing long style and short stamen and the other long stamen and short style.

ENDOSPERM : a tissue containing food material for developing embryo lying within a seed.

**Entomophilous** (C. U. 1917) : insect-pollinated.

**Epicalyx** (C. U. 1919, 1920, 1921) : bracteoles occurring below the calyx of a flower.

**Epigynous** (C. U. 1916) : a flower with the gynaecium united with a cup-shaped thalamus.

EPIPETALOUS : stamens attached to the petals.

**Epiphyte** (C. U. 1919) : a plant which grows on the bark of other plants and derives nourishment either from the mineral matters deposited on the bark or from the particles of dust floating in the air.

EXALBUMINOUS : a seed in which all the food-storing tissue has been consumed by the developing embryo which lies in direct contact with the seed-coats.

**Excurrent** (C. U. 1917) : stem with racemose branching.

FOLLICLE : superior, one-celled, one—or few-seeded, dry, dehiscent simple fruit formed from a monocarpellary ovary, dehiscing by one suture only.

FUNICLE : stalk to which the seed is attached.

**Gamete** (C. U. 1910, 1921) : sexual mass of protoplasm.

GAMETOPHYTE : in the life-cycle of a plant, the stage which produces the gametes.

**Geotropism** (C. U. 1910) : directive action of gravity on plant-organs.

**Graft** (C. U. 1917) : a young shoot, the *graft*, of one plant is fixed to the stem or branch of another allied plant, the *stock* ; the graft is subsequently separated from the stock and grows into a new plant.

**Guard-cells** (C. U. 1917) : cells enclosing a stoma.

**Glume** (C. U. 1920) : a bract at the base of inflorescence of plants like Grass.

**Gynandrous** (C. U. 1921) : stamens attached to the gynæcium.

HASTATE : a lamina pointed towards the apex and hollowed at the base into two acute lobes which are situated more or less at right angles to the petiole.

HAUSTORIA : root-like structures of some parasites.

HARD BAST : fibrous sclerenchyma belonging to the primary cortex and lying outside the phloem.

**Heliotropism** (C. U. 1917) : directive effect of light on growing plant-organs.

**Hypanthodium** (C. U. 1921) : a racemose inflorescence with a cup-shaped axis bearing flowers on the inner surface of the cup.

**Hypogynous** (C. U. 1916, 1919) : a flower in which the gynæcium is situated above the androecium, corolla and calyx.

**Interpetiolar stipules** (C. U. 1919, 1920) : stipules of two opposite leaves uniting to form a whorl with the leaves.

INTEGUMENT : coat of the ovule.

IMBRICATE : if the margins of some leaves overlap others in a bud.

IMPARIPINNATE : a pinnately compound leaf having a leaflet at the top of the common stalk.

**Involucre** (C. U. 1921) : a circle of bracts at the base of an inflorescence.

ISOBILATERAL : a flower which can be divided into similar halves through two planes.

**Labellum** (C. U. 1919, 1921) : In Orchids and some other flowers, a well-differentiated leaf forming the landing place for insects.

LANCEOLATE : an elongated lamina which is gradually pointed both towards the base and apex.

LATEX : milky, sometimes watery or yellowish, liquid occurring within a laticiferous tissue.

**Legume** (C. U. 1919.) : superior, one-celled, one—or many-seeded, monocarpellary, dry, dehiscent, simple fruit dehiscing by both ventral and dorsal sutures.

LENTICEL : an organ in the cork to communicate air, water-vapour and gases.

LEUCOPLAST (or Leucoplastid) : : a colourless plastid generally occurring in the parts of plants which are shut up from light. On being exposed to light, it becomes chloroplastid. Its function is to prepare starch from soluble carbohydrates.

LIGULE :a membraneous structure occurring at the junction of sheathing petiole and blade generally of plants like Grass.

LOMENTUM : a kind of legume constricted between the seeds ; sometimes lomentum may be indehiscent or schizocarpic.

LODICULES : generally two small green scales representing the perianth of the flower of Grass.

LYRATE : a pinnately—veined simple leaf with a large rounded apical lobe, the lobes below being gradually smaller and rounded.

MERISTEM (or Meristematic tissue) : an undifferentiated tissue composed of cells which are capable of division.

**Monadelphous (C. U. 1920)** : stamens with filaments united together into a single bundle.

**Monochlamydeous (C. U. 1915)** : a flower possessing either calyx or corolla.

MONOCLINOUS (or bisexual or hermaphrodite) : a flower possessing both androecium and gynæcium.

**Monoecious( C. U. 1915)** : a plant bearing staminate and pistillate flowers.

**Mucronate (C. U. 1915)** : rounded apex of a lamina with a short hard or soft point at the centre.

NECTARY : a gland situated generally on the thalamus and occasionally on other parts of a flower. It secretes odorous or sweet liquid to attract insects.

**Nucellus (C. U. 1921)** : a tissue surrounded by the integument of the ovule.

**Nucleolus (C. U. 1910)** : a granular body, probably a form of reserve food, occurring in the meshes of chromatin-network of nucleus.

**Ochrea (C. U. 1921)** : a tubular sheath formed round the base of the internode by the union of the margins of stipules.

OCTANTS : eight cells produced from the division of the oospore and giving rise to the embryo.

OFFSET : a short and stout branch which, arising in the axil of a foliage-leaf, grows horizontally on the surface of the ground giving off, at intervals, small scale-leaves and a cluster of adventitious roots.

OVATE : a lamina which is more or less rounded towards the base and pointed towards the apex.

PALISADE PARENCHYMA : two or more rows of cells elongated at right angles to the surface of the lamina and containing a large number of chloroplastids.

**Pollinia** (C. U. 1921) : masses of pollen-grains as in Orchids.

**Papilionaceous** (C. U. 1920, 1921) : an irregular polypetalous corolla composed of five petals, one of which is posterior and commonly larger than the others and is termed the *standard* or *vexillum*. In front of the standard, there are two petals which are usually more or less united and form a somewhat boat-shaped cavity known as the *keel* or *carina*. On the sides of the keel, there are two petals constituting the *wings* or *alæ*.

PAPPUS : hairs representing calyx.

PARASITE : a living organism deriving food material from another living organism.

PARIPINNATE : a pinnately compound leaf having no leaflet at the top of the common stalk.

PARTHENOGENESIS : process by which a sexual cell develops into the normal product of fertilisation without a preceding sexual act.

PEDATE : a palmately veined simple leaf in which the veins of the first order are also palmately branched.

PEDICEL : the stalk of a flower.

PEDUNCLE : the main axis of the inflorescence.

**Peltate** (C. U. 1916) : a palmately veined, more or less circular simple leaf in which the petiole is attached to the middle of the lamina.

PERIBLEM : a layer or several layers of cells between the dermatogen and plerome.

PERICARP : the portion of the fruit outside the seed.

**Perigynous** (C. U. 1916) : a flower with a flattened or cup-shaped thalamus bearing the sepals, petals and stamens on the edge of the plate or cup and the carpels at the base of the cup or in the middle of the plate or on an outgrowth.

PERISPERM : a portion of the nucellus containing food material for the developing embryo.

PHELLOGEN (or cork-cambium) : a meristematic tissue which produces cork and generally secondary cortex.

PINNATIFID : a pinnate type of lamina with the incision reaching less than half the distance between the margin and midrib.

PINNATIPARTITE : a pinnate type of lamina with the incision reaching more than half the distance between the margin and midrib.

PINNATISECT : a pinnate type of lamina with the incision almost reaching the midrib.

**Plerome** (C. U. 1910) : a solid mass of somewhat elongated cells occurring in the centre of the growing-point.

PROCAMBIUM : elongated cells of the plerome which subsequently give rise to the vascular bundles.

PROTHALLUS (or Prothallium) : gametophyte generation of plant.

PROTANDRY : ripening of the anther of a flower before the ripening of its ovule.

PROTOGYNY : ripening of the ovule of a flower before the ripening of its anther.

PROTOPHLOEM : first differentiated phloem from the procambium.

PROTOXYLEM : first differentiated xylem from the procambium.

**Pulvinus** (C. U. 1921) : a cushion of tissue at the leaf-base.

**Racemose** (C. U. 1915) : *Branching :* if the main axis

of the plant continues its growth and is not overtopped by any of its branches. *Inflorescence :* when the main axis of the inflorescence is never terminated by a flower and continues to grow steadily onwards developing laterally flowers or branches bearing flowers.

RACHIS : stalk to which the leaflets of a compound leaf are attached.

RENIFORM : a lamina with a rounded apex and notched base which is more or less elongated transversely.

RHIZOID : structure functioning as root.

RHIZOME : an underground stem growing horizontally just below the surface of the ground and bearing scale-leaves, buds and sometimes adventitious roots.

RUNCINATE : a pinnately veined simple leaf with a large triangular apical lobe and gradually smaller basal lobes which point downwards.

Samara (C. U. 1916) : superior, two—or more-celled, one—or few-seeded dry, indehiscent simple fruit in which the pericarp is flattened out into a thin membrane.

Saprophyte (C. U. 1917) : a living organism obtaining food from decaying organic matter.

SAGITTATE : a lamina pointed towards the apex and hollowed at the base into two acute lobes which point downwards.

Scape (C. U. 1916) : a peduncle arising at the level of or under the ground.

Scutellum (C. U. 1910) : an outgrowth from the cotyledon of a monocotyledonous seed ; through the scutellum, the embryo draws nourishment from the endosperm.

SILICULA : a superior, falsely two-celled, many-seeded, *broad and short* fruit dehiscing by two valves which separate from below upwards and leave the seeds attached to two parietal placentas which are usually connected together by false membrane called the *replum.*

Siliqua (C. U. 1916) : a superior, falsely two-celled, many-seeded, *long and narrow* fruit dehiscing by two valves

which separate from below upwards and leave the seeds attached to two parietal placentas which are usually connected together by a false membrane called the *replum.*

**Sinuous anther** (C. U. 1920) : undulating anther as in Cucurbitaceae.

**Sieve-tube** (C. U. 1917) : a tube formed from a row of cells, the wall common to two adjacent cells possessing a number of apertures ; the common wall is known as *the sieve-plate* on both sides of which lies a thin layer of a peculiar substance known as the *callus.*

**Sorosis** (C. U. 1916, 1921) : a succulent or woody composite fruit formed by the close union of the flowers with the axis of the inflorescence.

**Sorus** (C. U. 1921) : a group of sporangia.

**Spadix** (C. U. 1919) : a racemose inflorescence consisting of a fleshy axis which usually bears both male and female flowers and which is generally enclosed or subtended by a large bract called the *spathe.*

SPATHULATE : a lamina which is broad and rounded at the apex and is gradually drawn out towards the base.

SPATHE : a bract subtending or enclosing the inflorescence known as the *spadix.*

SPICATE : flowers arranged in a spike or like a spike. A spike consists of an axis bearing stalkless flowers.

**Spongy parenchyma** (C. U. 1910) : parenchymatous cells of lamina with copious intercellular spaces.

**Spore** (C. U. 1910) : asexual reproductive cell.

SPOROPHYLL : a spore-bearing leaf.

SPOROPHYTE : in the life cyle of a plant, the stage which bears spores.

**Staminode** (C. U. 1920, 1921) : a functionless or rudimentary stamen.

STELE : strand or cylinder of tissue developed from the plerome and giving rise to vascular bundles.

STIPULES : a pair of outgrowths, one on each side of the leaf-base.

**Stolon (or Runner) C. U. 1916, 1921 :** a branch which arises in the axil of a foliage-leaf, grows horizontally on the surface of the ground, and produces, at intervals, scale-leaves and adventitious roots.

STOMATA : apertures largely present in the epidermis of the leaf of sporophyte. Each stoma is bounded by two, sometimes one, specialised epidermal cells known as the *guard-cells*.

SUBULATE : a very narrow lamina which is gradually pointed from the base to a very fine point.

SUCKER : a branch which arises below the level of the ground, then grows upwards and develops roots and aerial shoots.

SUSPENSOR : a tissue which, by development, pushes the embryo into the cotyledon.

SYMBIOSIS : association ,for mutual advantage, of a chlorophyll-containing plant with a plant which does not possess chlorophyll.

**Syngenesious (C. U. 1919) :** united anthers, the filaments remaining free.

**Tendril (C. U. 1921) :** a thread-like structure by which a plant climbs up a support.

**Tetradynamous (C. U. 1919. 1920) :** six stamens, four of one length and two of another.

**Thallus (C. U. 1921) :** a plant-body which is not differentiated into distinct members.

**Tuber (C. U. 1919) :** a swollen underground stem or branch containing a large amount of food material and bearing on its surface a number of buds called the *eyes*.

**Umbellate (C. U. 1915) :** flowers arranged in an umbel or like an umbel. An *umbel* is a racemose inflorescence with a compressed axis bearing flowers which are placed on stalks of more or less equal lengths, the bracts of the flowers forming usually an *involucre*.

VALVATE : if in a bud, the leaves touch one another by their margins.

**Vernation** (C. U. 1919): mode of arrangement of leaves with respect to one another in a vegetative bud.

**Verticillaster** (C. U. 1921) : a peculiar form of cymose inflorescence consisting of either sessile or short-stalked flowers apparently arranged in whorls round the stem. Each whorl consists of two clusters of flowers in the axils of bracts. Each cluster has its oldest flower in the middle and is therefore cymose. In its first branching, it is a *dichasium* but in its later branching, it is a *monochasium.*

**Zygomorphic** (C. U. 1917) : a flower which can be divided into similar halves by only one plane.

**40. Describe the following Natural orders :—**

**Gramineæ, Cyperaceæ,** PALMACEÆ, ARACEÆ, LEMNACEÆ, COMMELYNACEÆ, **Liliaceæ,** AMARYLLIDACEAÆ, IRIDACEÆ, **Scitaminaceæ, Orchidaceæ,** PIPERACEÆ, **Urticaceæ,** POLYGONACEÆ, **Amarantaceæ,** NYCTAGINACEÆ, PORTULACACEÆ, CARYOPHYLLACEÆ, NYMPHAEACEÆ, RANUNCULACEÆ, **Menispermaceæ,** MAGNOLIACEÆ, **Anonaceæ, Papaveraceæ,** CAPPARIDACEÆ, **Cruciferæ,** ROSACEÆ, **Leguminosæ, Geraniaceæ,** OXALIDACEÆ, **Rutaceæ, Euphorbiaceæ, Anacardiaceæ, Sapindaceæ,** VITACEÆ, **Rhamnaceæ, Tiliaceæ, Malvaceæ, Sterculiaceæ, Passifloraceæ, Begoniaceæ,** CACTACEÆ, **Lythraceæ, Combretaceæ, Myrtaceæ, Umbelliferæ,** SAPOTACEAE, **Apocynaceæ, Asclepiadaceæ, Convolvulaceæ, Boraginaceæ, Verbenaceæ, Labiatæ, Solanaceæ, Scrophulariaceæ, Bignoniaceæ, Acanthaceæ, Rubiaceæ, Cucurbitaceæ,** CAMPANULACEÆ, **Compositæ.**

## MONOCOTYLEDONS.

*Cohort* : GLUMIFLORAE.

Flowers naked, rarely with hair-like or true perianth covered by glumes ; ovary one—locular with one ovule.

Natural Orders : **Gramineæ & Cyperaceæ.**

# GRAMINEÆ (Monocot.) Fig. 233.

## (C U. 1909, 1912, 1913, 1915, 1918, 1920).

(Words in italics denote *distinguishing characters*). EXAMPLES : ধান (Dhan, *Oryza sativa*) ; ভুট্টা (Bhutta, *Zea Maize*) ; আখ (Akh, Sugarcane, *Saccharum officinarum*) ; জব (Jab, Oat, *Avena sativa*) ; গম (Gom, Wheat, *Triticum vulgare*) ; বাঁশ (Bans, Bamboo, *Bambusa arundinacea*).

FLORAL FORMULÆ : $K_0C_0A_{3+0}G_{\underline{1}}$ or if the lodicules be considered as representing the perianth, $K_0C_{0+2}A_{3+0}G_{\underline{1}}$.

**Description.**

HABIT : herbs, a few e.g. bamboo, almost tree-like, often with hollow internodes and solid joints at the nodes. LEAVES ; simple, sessile, parallel-veined, alternate, *ligulate* with leaf-base encircling the stem. INFLORESCENCE : spikelets, at the base of which a number of bracts, called *glumes*, are present ; the spikelets are again arranged in spikes, racemes or panicles. FLOWERS : hermaphrodite or unisexual ; rarely each is enclosed by two bracts called *palæ*. PERIANTH : *absent or represented by a few* (*generally* 2) *small green scales called lodicules.* ANDROECIUM : stamens generally 3, hypogynous with long filaments and large versatile anthers. GYNAECIUM : *carpel one*, ovary superior, unilocular with one ovule ; stigma, hairy. FRUIT : *caryopsis*. SEED : embryo at one side of the endosperm.

POLLINATION : Mostly wind-pollinated. A few e.g. wheat are self-pollinated by producing cleistogamous flowers in damp weather.

DISTRIBUTION : A very large Order with over 300 genera all over the world, *mainly over great* tracts in the temperate regions.

AFFINITIES : The nearest allies of Gramineæ, in both habit and structure, are the *Cyperaceæ*. The structure of the seed of Gramineæ approaches that of *Araceæ*. The stems of Bambusa (Gramineæ) have the habit even of some *Palmaceæ*.

PROPERTIES & USES: The cereal grasses of this Natural Order afford food to a large proportion of the earth's inhabitants. Many grasses are valuable as fodder for domestic animals, or for hay. The bamboos supply many of the wants of the natives of tropical countries.

**Inter. Questions on Gramineae from 1909-22.**

1. Describe a member of the Gramineæ. Name the plant that you are describing and underline in your description those features which are characteristic of this Order. (C U. 1909.)

2. Refer the following plants to their Natural Orders and give reasons for your answer: the Mustard plant, the Melon, the Tulsi plant, the Rice plant. (C. U. 1912).

3. Give the characteristics of the Natural Order, Gramineae. Describe any common plant belonging to this Order. (C. U. 1913.)

4. Describe in detail the characteristic features of the Natural Order, Gramineae. (C. U. 1915).

5. Describe as fully as you can the family—*Gramineae* (C U. 1918).

6. Give the chief characteristics of the Natural Order, *Graminaceae* (C. U. 1920).

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## CYPERACEAE (Monocot.) Fig. 224

(Words in italics denote *distinguishing characters*).

EXAMPLE: মুথা (Mutho, *Cyperus rotundus*).

FLORAL FORMULA: $K_3\ C_3\ A_{3+3}$ or $_3\ G_{(3)}$ or in *unisexual flowers*, $K_0C_0A_{3+3}$ and $K_0C_0G_{(3)}$ or $_{(2)}$.

**Description.**

HABIT: Grass-like plants, mostly perennial herbs with generally *solid*, cylindrical or 3—cornered rhizome bearing *three rows of leaves*. The leaf is sheathing at the base but the *sheath is tubular and entire, not split as in a Grass*. INFLORESCENCE: spikelet. FLOWER: hermaphrodite or unisexual, each is borne in the axil of a glume. PERIANTH: absent or of 3-6 or more *hypogynous* bristles or scales. ANDROECIUM: stamens 1-3. GYNÆCIUM: car-

pels 3 or sometimes 2 forming a 1-locular ovary which contains 1 erect, anatropous ovule. FRUIT : achene. SEED : embryo enclosed in the endosperm.

POLLINATION : Mostly wind-pollinated.

AFFINITIES : Cyperaceæ resemble GRAMINEÆ in many respects but they have several marked distinctive characters e.g. *tubular leaf-sheaths*, usually *angular and solid stems*, general *reduction of the perianth* and the *embryo being enclosed in the endosperm.* From RESTIACEÆ, they are distinguished by the *erect seeds*, 1*—locular ovary formed of 2 or 3 carpels* and the *leaf-sheaths not being free at the edges*.

DISTRIBUTION : Universally distributed, especially in marshes and running streams.

PROPERTIES & USES : The plants of this Natural Order are of little economic value. Some have bitter and astringent properties, while others can increase perspiration.

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*Cohort :* PRINCIPES.

Flowers usually cyclic, trimerous, hypogynous, regular or rarely zygomorphic. Stamens usually 6. Carpels 3, usually each with 1 fleshy ovule. Inflorescence, a simple or compound spadix.

Natural Order : PALMACEÆ.

**PALMACEAE (Monocot.) Figs. 225, 226, 227.**

(Words in italics denote *distinguishing characters*).

EXAMPLES : তাল (Tal, *Borassus flabellifer*) ; নারিকেল (Narikel, Cocoanut, *Cocos nucifera*) ; খেজুর (Khejur, Date, *Phoenix sylvestris*).

FLORAL FORMULA : $P_{3+3}\ A_{3+3}\ \underline{G_{(3) \text{ or } 3}}$.

**Description.**

HABIT : Trees or shrubs, generally unbranched with a terminal cluster of LEAVES, the stalks of which are sheathing at the base. INFLORESCENCE : generally a branched spadix, sometimes a panicle. FLOWERS : hermaphrodite or unisexual. PERIANTH : two-whorled, each whorl con-

sists of 3 sepaloid leaves. ANDROECIUM : stamens usually 6, sometimes 3 or numerous, hypogynous or perigynous. GYNÆCIUM : carpels 3 which are free or united into 1-3—celled ovary ; ovule 1-2 in each carpel, anatropous ; stigmas 3 usually sessile. FRUIT : 1-seeded drupe or berry. SEED : large with a minute embryo embedded in a horny, fleshy or bony endosperm.

POLLINATION : wind-pollinated or insect-pollinated.

DISTRIBUTION : mainly tropical.

AFFINITIES : The stem of Calamoid Palms bears much resemblance to that of the Bamboo (*Gramineæ*). The spadiciform inflorescence unfolding from within a large foliaceous spathe and the structure of the perianth connect the Palms with the *Araceæ*. The two-whorled trimerous perianth, 6 stamens and 3—carpellary superior ovary, approximate Palmaceæ to the *Liliaceæ* but the habit, fruits and seeds of Palmaceæ differ in almost every respect from those of the Liliaceæ.

PROPERTIES & USES : The plants of this Natural Order possess juices and secretions which furnish sugar, starch, oil, wax and resins ; fermentation of the juices of many produces spirituous liquids . Some have edible fruits of great importance. The buds of others are sometimes used as food. The leaves of many plants are applicable to countless uses, from thatching huts to plaiting mats and hats. The fibrous substance of the sheathing petioles furnishes materials for cordage, or, when more solid, supplies a valuable substitute for bristles and whalebone. The fibrous husks of the fruits afford textile materials. The stems of some kinds are used in building but do not yield plank-timber.

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*Cohort :* SPATHIFLORÆ.

Natural Orders : ARACEÆ & LEMNACEÆ.

### ARACEÆ (Monocot.) Fig. 228.

(Words in italics denote *distinguishing characters*).
EXAMPLES : কচু (Kachhu, *Colocasia Antiquorum*) ; মানকচু

(Man Kachhu, *Alocasia indica*); ওল (Ol, *Amorphophallus campanulatus*).

FLORAL FORMULA : $K_nC_nA_{n+n}G_{(\underline{n})}$ where $n=2$ or 3.

**Description.**

HABIT : Herbs with aerial stems, tubers or rhizomes, climbing shrubs, climbing epiphytes, marsh plants and one water plant. LEAVES : simple or compound, pinnately or palmately divided. INFLORESCENCE : spadix generally with a spathe. FLOWERS : generally unisexual, sometimes hermaphrodite ; when unisexual, the staminate flowers occur above the pistillate flowers. PERIANTH : absent or represented by 4-6 scales. ANDROECIUM : stamens 1-8, the filaments and anthers of which are generally united into a single bundle ; staminodes are often present and these may also be united into a single bundle. GYNÆCIUM : carpels united in a 1-3-celled ovary ; ovules in each cell, one or more. FRUIT : a berry. SEED : possesses a large endosperm but is sometimes exalbuminous ; embryo straight and minute.

POLLINATION : Mostly insect-pollinated, protogynous.

DISTRIBUTION : Mostly tropical.

AFFINITIES : Some genera of this Natural Order resemble the *Typhaceæ* or *Cyperaceæ*, others have relations with the *Pandanaceæ* and *Palmaceæ*. From *Naiadaceæ*, in which the inflorescence is hardly spadiciflorous, the Araceæ are easily distinguished by the character of their seeds. The *Lemnaceæ* are closely related to this Natural Order.

PROPERTIES & USES : The juices of the Araceæ are generally acrid and dangerous, some are very poisonous but the poisonous principles are dispelled by heat. The corms and rhizomes of many contain starch and are used as food.

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## LEMNACEAE (Monocot.) Fig. 229.

(Words in italics denote *distinguishing characters*).

**Description.**

HABIT : free swimming perennial water-plants with *no leaves*. INFLORESCENCE : consists of *two male flowers* and *one female flower* lying naked or enclosed in a membraneous spathe. FLOWER : Unisexual, monoecious. PERIANTH : absent. ANDROECIUM : stamen 1 in male flower. GYNÆCIUM : carpel 1 in female flower ; ovary 1-locular containing 1-6 ovules. FRUIT : one or more-seeded utricle. SEED : contains a kind of lid and small amount of endosperm.

AFFINITIES : Related to *Araceæ* and *Naiadaceæ*.

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*Cohort :* FARINOSÆ.

Flowers cyclic. Perianth 2-whorled, each whorl usually consisting of 3 parts. Stamens 6, or one whorl of 3 or all but 1 are sometimes absent. Ovules often orthotropous. Endosperm mealy.

Natural Order : COMMELYNACEÆ.

## COMMELYNACEAE (Monocot.)

**Description.**

HABIT ; herbs with jointed stems and sheathing alternate leaves. INFLORESCENCE : usually a scorpioid cyme. FLOWER : usually regular, blue and hermaphrodite. CALYX : sepals 3. COROLLA : petals3. ANDROECIUM : stamens 6, all fertile or some abortive, the filaments are sometimes clothed with hairs. GYNÆCIUM : carpels 3, or sometimes 2, united in a 3 or 2-celled superior ovary ; ovules orthotropous, solitary or few in each loculus. FRUIT : capsule or indehiscent. SEED : endospermous, often arillate.

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*Cohort :* LILIIFLORÆ.

Flowers cyclic, each whorl usually consists of 3 parts but sometimes 4 or 5 parts. Stamens usually 6. Ovules often anatropous.

Natural Orders : LILIACEÆ, AMARYLLIDACEÆ, IRIDACEÆ.

## LILIACEAE* (Monocot.) Figs. 230, 231, 232, 233, 234.

(Words in italics denote *distinguishing chara[illegible]*).

EXAMPLES : শতমূলি (Satamuli, *Asparagus racemosus*) ; পাঁজ ((Piyaj, Onion, *Allium Cepa*) ; লশুন (Lashun, Garlic, *Allium Sativum*) ; বিশালাঙ্গুলি (Bishalanguli, *Gloriosa superba*).

FLORAL FORMULA : $P_{3+3}A_{3+3}G_{(3)}$.

**Description.**

HABIT : chiefly herbs with perennial underground bulbs or rhizomes ; a few are shrubs or trees. LEAVES : simple, sheathing, parallel-veined. INFLORESCENCE : racemose or cymose, sometimes an umbel of cymes ; bracteoles are absent. FLOWERS : hermaphrodite, *hypogynous*. PERIANTH : 2-whorled, each whorl consisting of 3 parts which are free or united, generally petaloid. ANDROECIUM : stamens usually 6 with introrse anthers. GYNÆCIUM : carpels 3, united ; ovary usually superior, trilocular, placentation *axile*, with a double row of usually anatropous ovules in each loculus. FRUIT : a capsule or a berry. SEED : endospermous.

POLLINATION : insect-pollinated ; there are nectaries at the base of the petals or on the carpels.

DISTRIBUTION : universally distributed.

AFFINITIES : The superior ovary of the Liliaceæ separates them from *Amaryllidaceæ*. The plants of the Liliaceæ have a more distant affinity to the *Palms* and *Juncaceæ*.

PROPERTIES & USES : Many of the Liliaceæ have active properties and their juices, fibres and fruits afford products of value in the arts. Many are poisonous with acrid, purgative, emetic and sometimes narcotic action.

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### AMARYLLIDACEÆ (Monocot.) Figs. 235, 236.

(Words in italics denote *distinguishing characters*).

FLORAL FORMULA : $P_{(3+3)}A_{3+3}G_{(\overline{3})}$.

**Description.**

HABIT : perennials, with bulbs or rhizomes, many xerophytic. INFLORESCENCE : cymose, often a cymose umbel, usually borne on a scape. FLOWERS : hermaphrodite, *epigynous*. PERIANTH : two-whorled, each whorl consisting of 3 parts, petaloid, sometimes with a corona. ANDRŒCIUM : stamens 6 attached to bases of perianth segments, anthers *introrse*. GYNÆCIUM : carpels 3 united ; ovary *inferior* with axile placentation and numerous anatropous ovules. FRUIT : capsule or berry.

DISTRIBUTION : Chiefly South African and South American plants. AFFINITIES : This Natural Order differs from *Liliaceæ* by possessing *inferior* ovary and from *Iridaceæ* by possessing 6 *stamens and introrse anthers*.

PROPERTIES & USES : Some are emetic, purgative and even poisonous. The roots of some plants yield starch. Some plants possess sugary sap and excellent fibres in the leaves.

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## IRIDACEAE (Monocot.)

(Words in italics denote *distinguishing characters*).

EXAMPLE : দশ্‌বাইচণ্ডী (Dashbaichandi, *Belamcandæ chinensis*).

FLORAL FORMULA : $P_{(3+3)}A_3G\overline{(3)}$.

**Description.**

HABIT : perennials, with rhizome or corm (not bulb). LEAVES : generally in *two rows*, and successive leaves overlap at both sides. INFLORESCENCE : solitary or cymose. FLOWERS : hermaphrodite, epigynous. PERIANTH : two-whorled, consisting of 3 parts, petaloid and joined in a tube towards the base. ANDRŒCIUM : stamens 3, anthers *extrorse*. GYNÆCIUM : carpels 3 united ; style branched at the top, sometimes petaloid ; ovary inferior with numerous anatropous ovules ; placentation axile. FRUIT : capsule. SEED : endospermous.

POLLINATION : The pollination of an *Iris* is specially

interesting. The stigmatic surface is on a little flap on the petaloid style, not far from its tip. The stamens are hidden under the styles and dehisce extrorsely. In order to reach the honey at the base of the perianth-tube, the insect sits on one of the outer perianth leaves and pushes its body between the perianth and the stamen above. The stigma is touched as the insect enters the flower, and any pollen which may be on its back is scraped off by the flap, which is closed by the insect as it leaves the flower, so that self-pollination is prevented.

DISTRIBUTION : Chiefly found round the Mediterranean, in South Africa, Australia and tropical America.

AFFINITIES : The Iridaceæ approach the *Amaryllidaceæ* which, however, have 6 introrse stamens. The same character separates the epigynous *Bromeliaceæ*. *Orchidaceæ* differ in the gynandrous structure; *Zingiberaceæ* in their monandrous state as also in the character of their foliage. The *Burmanniaceæ* and *Xyridaceæ* differ in the position and number of the stamens.

PROPERTIES & USES : The juice of many of these plants is more or less acrid, purgative or emetic. Saffron consists of the stigmas of Saffron Crocus. Orris-root, used in perfumery, is the rhizome of *Iris florentina*. Some genera of this order yield garden-bulbs while others are more remarkable for their beautiful flowers. The corms and rhizomes of some are said to be eaten, on account of the starch they contain, by the Hottentots and other races.

*Cohort :* SCITAMINEÆ.

Flowers cyclic, trimerous, often with reduction of androecium even to 1 stamen, usually epigynous and zygomorphic; ovary usually 3—locular with large ovules; seeds usually with arils and with endosperm and perisperm.

NATURAL ORDER ; **Scitaminaceæ.**

**SCITAMINACEAE** or **ZINGIBERACEAE** * (Monocot.) **Fig. 68 (2).**

EXAMPLES : হলুদ (Halud, Turmeric, *Curcuma longa*);

আমআদা (Amada, *Curcuma Amada*); ভুঁইচাঁপা (Bhuichampa, *Kæmpferia rotunda*); অ্যারারুট (Arrowroot, *Maranta arundinacea*).

FLORAL FORMULA : $K_3C_3A_2$ or $_{0+1+2}G_{(3)}$.

HABIT : herbaceous perennials with a creeping rhizome. LEAVES : broad, with a sheathing petiole, pinnately parallel-veined. INFLORESCENCE : spike or racemose with spathaceous membranous bracts. FLOWERS : generally hermaphrodite, irregular. PERIANTH : two-whorled, the outer whorl generally sepaloid and consists of 3 parts ; the parts of the inner whorl are petaloid, united into a tube which is free or attached to the petaloid staminodes. ANDRŒCIUM : stamens only 1 perfect, the remainder replaced by petaloid staminodes, or 5 perfect with the sixth imperfect or undeveloped ; anthers 1—2—locular. GYNÆCIUM : carpels 3 united in a 3-celled, rarely 2-celled or 1-celled, *inferior* ovary. FRUIT : a 3-valved capsule or indehiscent, usually crowned by the remains of the perianth. SEED : often arillate, endospermous.

Scitaminaceæ is divided into three tribes—(1) ZINGIBERÆ ; (2) MUSEÆ ; (3) CANNEÆ or MARANTEÆ.

ZINGIBERÆ : example, আদ, ada (Zingibero fficinale). Calyx : gamosepalous. Stamens : in two whorls, the outer whorl contains 3 petaloid staminodes, one being abortive, or the outer whorl may be altogether unrepresented by staminodes ; the inner whorl contains 3 stamens, one perfect and the other two unite to form a structure called the *labellum*.

MUSEÆ : example, কাঁটালীকলা, Kantalikela (Musa sapientum). Plants are almost shrubby and very large. Leaves : large with long sheathing petioles which conjointly form a sort of false subærial stem. Inflorescence : spike. Flowers : pistillate at the base of the spike, perfect in the middle and staminate at the top ; bracts, generally coloured. Perianth : petaloid. Stamens : posterior one of the inner whorl, small or absent. Fruit : a berry having no seeds in the cultivated species.

CANNEÆ or MARANTEÆ : example, সর্ব্বজয়া, sarbbajaya

(Canna indica). Flower : asymmetrical. Calyx : sepaloid. Stamens : 6, the posterior one of the inner whorl perfect, rest become staminodes of which one is longer than others and is known as the *labellum*. Style : petaloid.

DISTRIBUTION : Mostly tropical.

AFFINITIES : The Scitaminaceæ are nearly related to the *Orchidaceæ*.

PROPERTIES & USES : The Scitaminaceæ are remarkable for the pleasant, aromatic and stimulant qualities of the rhizomes and seeds. Some are astringent, some produce pulpy fruit, many yield starch and some produce colouring-matters. The leaves of some are used for thatching huts or split up for plaited work of all kinds . The fibre of the petioles of many leaves is a valuable material.

——o——

*Cohort :* MICROSPERMÆ.

Flowers cyclic, trimerous, stamens often reduced to staminodes ; ovary inferior, 3 or 1—locular with indefinite ovules in each loculus.

Natural Order : **Orchidaceae.**

## ORCHIDACEAE (Monocot.) Figs 237, 238.

(Words in italics denote *important characteristics*).

EXAMPLE : রাস্না (Rashna, *Vanda Roxburghii*).

FLORAL FORMULA : $K_3C_3A_{1+2}\underline{G(3)}$.

HABIT : generally perennial herbs ; the tropical forms are mostly epiphytes with ærial roots, a few are saprophytes. The stem is either a rhizome or a tuber. LEAVES : simple, alternate, parallel-veined. INFLORESCENCE : spike, bracts present. FLOWERS : hermaphrodite, epigynous, very strongly zygomorphic ; in many cases, the ovary is so twisted that the anterior side of the flower appears to be posterior. PERIANTH : two-whorled, petaloid. The outer whorl is more or less regular, but the posterior leaf of the inner whorl, known as the *labellum*, is generally much developed ; the labellum serves as a landing— stage for insects. ANDRŒCIUM & GYNÆCIUM : stamen 1 with 2 pollen-sacs ; at

the base of the stamen there is a little prominence known as the *rostellum* which represents an abortive stigma. The functional stigmas are two sticky patches to the side and slightly below. Within the rostellum are two sticky balls, attached by elastic stalks to the contents of the pollen-sacs. The pollen-grains are in groups, united by threads, and the ends of these threads are collected together to form the elastic stalk of the pollen masses known as the *pollinia*. At the side of the anther there are two small white protuberances, known as *staminodes*, and they probably represent abortive stamens. The central part of the flower on which the stamen is borne is spoken of as the *column* or *gynostemium*. The ovary is unilocular with parietal placentation; the ovules are very small and numerous. FRUIT: a capsule splitting by six slits, one on each side of the midribs of the carpels. The very light seeds are blown out and dispersed by the wind. SEED: exalbuminous with an imperfectly developed embryo.

POLLINATION.

The flowers are adapted for cross-pollination by insects. An insect visiting a flower uses the labellum as the landing stage and thrusts its head into the spur. It cannot, however, obtain any honey until it has bitten through the delicate membrane lining the spur, for there is no free honey. While doing this, the insect's head will be bound to come in contact with the rostellum. The membrane protecting the two sticky discs splits, and is pressed down, so that they come in contact with, and become firmly attached to the insect's head. The cement of the discs hardens so quickly in the air that they cannot be detached, and as the insect withdraws its head the whole pollinia are removed. The pollinia are at first upright, but in a few seconds they will be seen to incline forward. If the insect now visits another flower, the pollinia by peculiar movements of stalks come exactly into contact with the stigmatic surfaces of the second flower. The whole pollinium does not adhere to the stigmatic surface, but some of the pollen-grains are torn from the threads, and the remainder may serve to pollinate another flower.

DISTRIBUTION : A cosmopolitan Order, especially abundant in the tropics.

AFFINITIES : In some plants belonging to the Orchidaceæ, the perianth is almost regular so as to resemble that of some of the genera of *Iridaceæ*. The suppression of 2 out of 3 stamens connects this Order with *Scitaminaceæ* where the same phenomenon exists in a different modification. Some plants belonging to the *Apostasiaceæ* differ from some Orchids chiefly in the free condition of the upper part of the style and the 3-locular ovary. Lindley regards them as connecting Orchidaceæ with *Amaryllidaceæ* through *Hypoxidaceæ*.

PROPERTIES & USES : The properties of these plants are generally unimportant. The tubers of some form nutritious food from the presence of a gummy substance. The most important plants, perhaps, are *Vanilla planifolia* and other species, and a species of *Sobralia*, the dried pulpy pods of which furnish the Vanilla used for flavouring chocolate and confectionary. A few others are described as having medicinal properties of various kinds.

## DICOTYLEDONS.

*Cohort :* **Piperales.**

Leaves simple with or without stipules. Flowers hermaphrodite or unisexual, very small in spikes. Perianth absent or one-whorled. Stamens 1—10. Carpels 1—4 free or united.

Natural Order : Piperaceæ.

EXAMPLES : পান (Pan, *Piper Betle*) ; গোলমরিচ (Golmarich, Black Pepper, *Piper nigrum*).

**Description.**

HABIT : herbs or shrubs with jointed stems ; usually aromatic. LEAVES : opposite, whorled or, by suppression, alternate, with or without stipules. INFLORESCENCE : catkin-like spike subtended by a bract. FLOWERS : hermaphrodite or dicœcious. PERIANTH : absent. ANDRŒCIUM : stamens 1—10. GYNÆCIUM : carpels 1—4 but generally all the carpels except *one* are suppressed ; in such cases the

ovary is 1—locular with 1 basal orthotropous ovule. In case of polycarpellary ovary, each carpel is many-ovuled. FRUIT : small, indehiscent in the 1—locular species or cocci or follicles in the polycarpellary species. SEED : contains both perisperm and endosperm.

DISTRIBUTION : abundant in tropics and hottest parts of America and East India islands.

AFFINITIES : the Piperaceæ are nearly related to the *Chloranthaceæ* and are more distantly related to the *Urticaceæ*. The Piperaceæ may be regarded as connecting the Dicotyledons with the Monocotyledons through the *Araceæ*, they themselves being somewhat anomalous forms of Monocotyledons.

PROPERTIES & USES : Pungent, aromatic, stimulant, more or less astringent, purgative or narcotic.

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*Cohort :* URTICALES.

Inflorescence : cymose ; panicle. Flowers : cyclic, monochlamydeous, rarely achlamydeous, usually 2-merous, regular. Carpels 2-1, ovary superior with 8 ovules. Fruit : a drupe or nut.

Natural Order : Urticaceæ.

## URTICACEAE (Dicot.) Figs. 240, 241, 242.

(Words in italics denote *distinguishing characters*).

Examples : কাঁটাল (Kantal, Jack-Fruit, *Artocarpus integrifolia*) ; বট (Bot, *Ficus indica*) ; অশ্বত্থ (Asvattha, *Ficus religiosa*) ; ডুমর (Dumar, *Ficus Cunia*) ; ভাং (Bhang, *Cannabis sativa*) ; তুঁত (Tunt, *Morus lævigata*).

**Description.**

HABIT : herbs, undershrubs or trees. LEAVES : simple, alternate or opposite, stipulate. INFLORESCENCE : cymose consisting of a fleshy, flat, concave or globose axis which is sometimes hollow and closed. FLOWERS : usually *unisexual*, monœcious or dicœcious, or, rarely polygamous,

regular. PERIANTH : sepaloid, generally two-whorled, each whorl consisting of 2 parts which are usually free. ANDRŒCIUM : stamens 4 in two whorls, opposite to the perianth leaves and bent inwards until mature but explode when ripe. GYNÆCIUM : carpels 1 or 2 ; ovary usually unilocular with a single *basal orthotropous* ovule. FRUIT : generally an achene or a drupe ; sometimes a soiosis or a syconus. SEED : albuminous.

POLLINATION : Wind-pollinated and insect-pollinated.

DISTRIBUTION : Much more abundant in the intertropical regions.

AFFINITIES : This Order is nearly related to the *Malvaceæ, Tiliaceæ* and *Euphorbiaceæ* but differs from them by possessing a simple ovary. There is a further relation to the *Chenopodiaceæ*.

PROPERTIES & USES : Many produce good timber-trees, edible fruits and valuable fibres. The bark of some is bitter and astringent. Some plants yield narcotic resinous product and the milky juice of many yields an acrid poisonous substance and caoutchouc. The seeds and milky juice of some are nutritious. The bark of some is used for making paper. Some yield dyes.

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*Cohort :* POLYGONALES.

Natural Order : POLYGONACEÆ.

## Polygonaceæ (Dicot.)

(Words in italics denote *distinguishing characters*).

EXAMPLE : পাকুরমূল (Pakurmul, *Polygonum Hydropiper*).

FLORAL FORMULA : $P_{3+3}A_{3+3}\underline{G_{(3)}}$.

HABIT : herbs with jointed stems, rarely shrubs or trees. LEAVES : alternate, simple ; stipules joined to form an *ochrea* inside the leaf-base surrounding the stem and axillary buds. INFLORESCENCE : primarily racemose but the partial inflorescences are usually cymose. FLOWERS :

hermaphrodite, regular, cyclic or acyclic. PERIANTH : generally two-whorled, each whorl consisting of 3 parts, or perianth-segments are 5, spirally arranged. ANDRŒCIUM : stamens 6 in two whorls or 5—8 in one whorl. GYNÆCIUM : carpels 3 united ; *ovary one-locular* with a *single, basal, orthotropous* ovule ; styles free. FRUIT : almost always a triangular nut. SEED : endospermous.

POLLINATION : Pollinated by wind or insects.

DISTRIBUTION : Chiefly north temperate.

AFFINITIES : Nearly related to the *Chenopodiaceæ* and *Amarantaceae* from which it differs by the ochrea, character of the perianth and single erect seed with its embryo having the radicle turned upward. It is also related to the *Nyctaginaceæ* and *Caryophyllaceæ*.

PROPERTIES & USES : The leaves of these plants frequently possess an acrid juice. Some are strongly astringent while the roots of many are more or less powerfully purgative. The starchy endosperm of some seeds furnishes a valuable substitute for corn.

*Cohort :* CENTROSPERMÆ.

Mostly herbs. Flowers cyclic or acyclic. Stamens often as many as and opposite to the perianth-leaves but also 1 to indefinite. Carpels 1 to indefinite, usually united ; ovary generally superior, rarely inferior, generally 1-locular, rarely multilocular ; ovules campylotropous, 1 to indefinite. Embryo curved.

Natural Orders : **Amarantaceæ**, NYCTAGINACEÆ, PORTULACACEÆ, CARYOPHYLLACEÆ.

## AMARANTACEÆ (Dicot.)

EXAMPLES : মোরগফুল (Morughphul, *Celosia cristata*) ; কাঁটানটে (Kantanota, *Amarantus spinosus*).

**Description.**

HABIT : herbs, rarely undershrubs, erect or with climbing branches. LEAVES : opposite or alternate. INFLORESCENCE : often primarily racemose but the partial inflorescences are always cymose, at first often dichasial but with a tendency to become scorpioid. FLOWERS : regular,

hermaphrodite, rarely unisexual; bracts and bracteoles are present. PERIANTH: simple, rarely absent, persistent after flowering, of 5, 3, 2 (rarely 1 or 4) leaves, more or less united, sepaloid. ANDRŒCIUM: stamens 1—5, opposite to the perianth leaves, hypogynous; anthers slightly bent inwards in bud and sometimes unilocular. GYNÆCIUM: carpel generally 1; ovary generally 1-locular and 1-ovuled. FRUIT: utricle, caryopsis or berry. SEED: pendulous, albuminous.

DISTRIBUTION: Abundant within the tropics.

AFFINITIES: Very nearly related to the *Chenopodiaceæ*.

PROPERTIES & USES: Generally with somewhat mucilaginous juice, seldom with active properties.

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## Nyctaginaceae (Dicot.)

EXAMPLE: কৃষ্ণকেলি (Krishnakeli, *Mirabilis Jalapa*).

**Description.**

HABIT: trees, shrubs or herbs whose stems are swollen at the nodes. LEAVES: simple, opposite or spirally arranged. INFLORESCENCE: cyme, rarely raceme, umbel or capitulum. FLOWERS: hermaphrodite or unisexual; usually there are several bracts constituting an epicalyx which is often coloured. PERIANTH; usually consists of 5 petaloid leaves which are persistent upon the ripe fruit. ANDRŒCIUM: stamens 1-30, filaments often of unequal lengths. GYNÆCIUM: ovary is monocarpellary containing a single ovule. FRUIT: an achene enclosed by the perianth leaves. SEED: albuminous.

DISTRIBUTION: Natives of warm climates.

AFFINITIES: This Natural Order is closely related to the *Polygonaceæ* but its inferior radicle and fruit enclosed by the perianth leaves are evident distinctions.

PROPERTIES & USES: The roots of the Nyctaginaceæ are generally purgative.

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## Portulacaceae (Dicot.).

EXAMPLE : নুনেশাক (Nuniyashak, Portulaca tuberosa).

**Description.**

HABIT : succulent herbs, rarely undershrubs. LEAVES : opposite or alternate, entire. CALYX : sepals 2, rarely 3 or 5. COROLLA : petals generally 4 or 5, free or united below. ANDRŒCIUM : stamens 4 to many. GYNÆCIUM : carpels usually 3, united into a superior 1-locular ovary with several stigmas and 2 to many ovules on a central basal placenta. FRUIT : a capsule. SEED : albuminous.

POLLINATION : Mostly insect-pollinated.

DISTRIBUTION : Natives of waste dry places in various parts of the world but chiefly at the Cape of Good Hope and in South America.

AFFINITIES : This Order is very closely related to the *Caryophyllaceæ* but it is distinguished by the number of sepals and the number and position of stamens. It is also related to the *Chenopodiaceæ*.

PROPERTIES & USES : Some plants possess edible tuber and some possess starchy root.

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## Caryophyllaceae (Dicot.).

EXAMPLE : গিমেশাক (Ghimashak, *Polycarpon Loeflingiæ*)

FLORAL FORMULA : $K_{(5)}C_5A_{5+5}\underline{G_{(5)}}$.

**Description.**

HABIT : Most are herbs, a few undershrubs, possessing stems swollen at the nodes. LEAVES : opposite, simple, usually entire, often stipulate. INFLORESCENCE : a dichasial cyme. FLOWERS : generally hermaphrodite and regular. CALYX : sepals 4 or 5, united or free, imbricate. COROLLA : petals 4 or 5, sometimes absent. ANDRŒCIUM : stamens 8 or 10, rarely fewer, generally in two whorls. GYNÆCIUM : carpels 2-5 united in a 1-locular ovary contain-

ing 2-many ovules. FRUITS : usually a capsule. SEED : albuminous.

POLLINATION : Insect-pollinated.

DISTRIBUTION : Mostly natives of temperate and cold climates extending to the Arctic regions and to almost the extreme limit attained by flowering plants or mountains.

AFFINITIES : The nearest relations of the Caryophyllaceæ are the *Illecebraceæ* and *Portulacaceæ*. The Illecebraceæ may be distinguished by their scarious stipules and utricular fruit, and the Portulacaceæ by the 2-leaved calyx and by the stamens, when equal to the sepals, being alternate or opposite to the petals. Some forms connect this Order with the *Amarantaceæ* and *Chenopodiaceæ*.

PROPERTIES & USES : The plants of this Order are generally devoid of active properties.

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*Cohort :* RANALES.

Natural Orders : NYMPHÆACEÆ, RANUNCULACEÆ, Menispermaceæ, MAGNOLIACEÆ, Anonaceæ.

## Nymphaeaceae (Dicot.)

EXAMPLE : পদ্ম (Padma, *Nelumbium speciosum*).

**Description.**

HABIT : water or marsh plants usually with rhizomes. Leaves : floating, cordate or peltate, or when submerged, much-dissected. FLOWERS : solitary, usually large and acyclic. CALYX, COROLLA & ANDROECIUM : partially petaloid sepals gradually passing into petals which also gradually pass into stamens. GYNÆCIUM : superior, semi-inferior or inferior ; carpels many, united or free : when free, the carpels are embedded in a curious torus ; ovules usually anatropous. FRUIT : indehiscent ripe carpels free or united into a fleshy berry-like mass. SEED : possesses both perisperm and endosperm and is often arillate.

DISTRIBUTION: Distributed throughout the whole of the Northern Hemisphere and more sparingly in the Southern Hemisphere.

AFFINITIES: This Order is related to the *Papaveraceæ* in the character of the ovary and *Ranunculaceæ* in the character of a highly developed disk. The character of the floral envelopes and stamens allies them to the *Magnoliaceæ*. The habit relates these plants to the *Hydrocharidaceæ* and the structure of the ovaries indicates some affinity with the *Alismaceæ*.

PROPERTIES & USES: These plants possess bitter, astringent and sedative properties. The flowers are said to be narcotic. Seeds of some, containing starch, are used as food.

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## RANUNCULACEÆ (Dicot.)

**Description.**

HABIT: most are herbaceous perennials with rhizomes, usually of condensed form. LEAVES: usually alternate with sheathing bases and often very much divided. INFLORESCENCE: more often cymose, sometimes racemose with a terminal flower. FLOWERS: regular or irregular, hermaphrodite or unisexual. THALAMUS: usually elongated. PERIANTH: either consisting of a petaloid calyx, or of calyx and corolla usually spiral. ANDRŒCIUM: stamens usually spiral. ANDROECIUM: stamens indefinite in number and spiral. GYNÆCIUM: carpels many and spiral; ovary apocarpous; ovules many but, in some cases, reduced to one. FRUIT: a group of achenes or follicles, sometimes a capsule or berry. SEED: albuminous.

POLLINATION: Insect-pollinated.

DISTRIBUTION: Abundant in damp, cool climates and are scarcely met with in the tropics, except on mountains.

AFFINITIES: The structure of the essential organs of this Order allies them closely to the *Magnoliaceæ* and

*Dilleniaceæ*, the former of which have distinct stipules while the latter have arillate seeds ; both differ in habit. Some are closely related to the *Berberidaceæ* from which, however, they differ in the indefinite stamens and in the sutural dehiscence of the anthers. From the *Nymphæaceæ* and *Papaveraceæ*, they are distinguished by distinct carpels. Relations exist also with the *Rosaceæ* from which this Order is known by its hypogynous stamens and general properties.

PROPERTIES & USES : The plants of this Order generally possess acrid and more or less narcotic properties, some being virulent poisons. The poisonous property resides in the watery juice and, in most cases, volatile and capable of dissipation by heat. The seeds of some are drastic purgatives and emetics. Some of the milder plants are used as tonics on account of the powerful bitter they contain.

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## MENISPERMACEÆ (Dicot.)

EXAMPLE : গুলঞ্চ (Gulancha, *Tinospora cordifolia*).

FLORAL FORMULA : $K_{3+3}C_{3+3}A_{3+3}G_{(3)}$.

**Description.**

HABIT : mostly climbing shrubs. LEAVES : simple, alternate, palmate or peltate. INFLORESCENCE : generally a raceme. FLOWERS : unisexual, usually dioecious, rarely perfect or polygamous. CALYX : sepals 6, rarely 1-4 or 9-12, in two whorls. COROLLA : petals 6, rarely 5-1 or absent, in two whorls, free or united. ANDRŒCIUM : stamens usually 6, opposite to each petal. GYNÆCIUM : carpels 3, rarely 1, or 6-12, free ; ovule 1, rarely 2, generally amphitropous. FRUIT : a drupe or an achene. SEED : albuminous.

DISTRIBUTION : Natives of the tropics of Asia and America : a few are found in more temperate regions.

AFFINITIES : This Order is related to the *Anonaceæ* and *Berberidaceæ*. Its nearest neighbours are the *Lardizaba-*

*laceæ* and *Schizandraceæ*. It is also distantly related to the *Magnoliaceæ* but its habit, generally unisexual flowers and absence of stipules separate it from that Order.

PROPERTIES & USES : Some are poisonous and narcotic. The roots and seeds of some are used as tonics and diuretics.

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## Magnoliaceæ (Dicot.)

EXAMPLE : চাঁপা (Champa, *Michelia Champaca*).

**Description.**

HABIT : Trees or shurbs, sometimes climbing. LEAVES : simple, alternate, sometimes stipulate. FLOWERS : hermaphrodite or unisexual and its whorls are generally spiral, sometimes cyclic. PERIANTH : generally petaloid and consists usually of three alternating trimerous whorls, one of sepals and two of petals. ANDROECIUM : stamens many, spirally arranged. GYNÆCIUM : carpels many, free or partly united, arranged spirally on a long receptacle. FRUIT : a follicle, berry or samara. SEED : albuminous.

POLLINATION : Insect-pollinated.

DISTRIBUTION : Abundant in the Southern states of North America. Some occur also in the West India Islands, Japan, China and India. A few occur in the extreme south of South America, Australia and New Zealand.

AFFINITIES : This Order is closely related to the *Dilleniaceæ* but is distinguished by its 3-merous flowers and, in many cases, by the stipules. Its imbricated Corolla and homogenous endosperm separate it from the *Anonaceæ*. The character of flowers indicates a relationship with the *Schizandraceæ*.

PROPERTIES & USES : Bitter tonic or aromatic properties in the bark and excessively fragrant blossoms are the most striking qualities of the plants of this Order.

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## ANONACEAE (Dicot.)

EXAMPLES : কাঁটালিচাঁপা (Kantalichampa, *Artabotrys odoratissimus*) ; আতা (Ata, Custard-apple, *Anona squamosa*) ; নোনা (Nona, *Anona reticulata*) ; দেবদারু (Debdaru, *Polyalthia longifolia*).

FLORAL FORMULA : $P_{3+3+3}$ A many G *many*.

**Description.**

HABIT : trees or shrubs, sometimes climbing. LEAVES : simple, alternate, entire. FLOWERS : hermaphrodite, rarely unisexual, regular. PERIANTH : usually consists of three whorls, one or two outer whorls are sepaloid. ANDROECIUM : stamens many, rarely few, closely arranged on the torus. GYNÆCIUM : carpels 1-many, free or rarely united ; ovules usually many, anatropous. FRUIT : commonly an aggregate of berries which sometimes fuse with the torus. SEED : generally contains ruminate endosperm.

DISTRIBUTION : Natives of the tropical regions of Asia, Africa and America.

AFFINITIES : This Order is separated from the *Magnoliaceæ* by the absence of stipules, valvate æstivation of corolla and the form of anthers. Ruminate endosperm of this Order indicates a relationship to the *Myristicaceæ*. It is also distantly related to the *Berberidaceæ* and *Menispermaceae*.

PROPERTIES & USES : These plants are generally aromatic and fragrant. Some yield sweet, succulent fruits.

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*Cohort :* RHOCADALES.

Flowers cyclic, hypogynous, regular or irregular, dichlamydeous, rarely monochlamydeous ; ovary superior.

Natural Orders : Papaveraceæ, CAPPARIDACEÆ, Cruciferæ.

# PAPAVERACEAE (Dicot.) Fig. 244.

(Words in italics denote *distinguishing characters*).

EXAMPLES : আফিম (Opium Poppy, *Papaver somniferum*) ; শেয়ালকাঁটা (Shialkanta, *Argemone mexicana*).

FLORAL FORMULA : $K_2C_{2+2}$ A many $G_{(2-8)}$.

**Description.**

HABIT : many are annual herbs with milky, watery or coloured *latex*. LEAVES : alternate, pinnately divided, often hairy. FLOWERS : hermaphrodite, *regular*, hypogynous. *Calyx* : sepals 2, free, fall off as the flower opens. COROLLA : petals 4, in two whorls, imbricate or crumpled in the bud. ANDRŒCIUM : *stamens many in alternating whorls*. GYNÆCIUM : carpels 2 to many, united ; ovary superior, containing numerous ovules on *parietal placentas* which project inwards. FRUIT : a capsule opening by pores or valves. SEED : contains *oily endosperm*.

POLLINATION : By insects which visit the flowers for pollen because the flowers produce no honey.

DISTRIBUTION : Mainly natives of Europe.

AFFINITIES : This Order is nearly related to the *Fumariaceæ* from which it differs by having irregular flowers, diadelphous stamens and a watery juice. The quaternary arrangement of the floral envelopes and the pod-shaped ovary cause a close resemblance to the *Cruciferæ* and *Capparidaceæ* from which, however, there is a marked distinction in the character of the endosperm of the seed and narcotic milky juice. It is also related to the *Nymphaeaceæ* by the general structure of the flower.

PROPERTIES & USES : The milky or coloured juice of this Order is generally powerfully narcotic, sometimes acrid. The opium is the dried milky juice obtained from the unripe capsule. The seeds of the capsule yield a fixed oil which is quite harmless and is used both by itself and as a means of adulterating olive oil ; the oil-cake is also used for feeding cattle. The yellow acrid juice of some is poisonous. The red juice of the root of a few plants possesses emetic and purgative properties.

## CAPPARIDACEAE (Dicot.)

EXAMPLES : হর্হরে (Harhara, *Cleome Viscosa*).

FLORAL FORMULA : $K_{2+2}C\times 4A_{2+2}$ or more$\underline{G(2)}$ or more.

**Description.**

HABIT : herbs or shrubs, erect or climbing, rarely trees. LEAVES : alternate, rarely opposite, simple or palmately compound ; stipules frequently present, herbaceous or reduced to spines or glands. INFLORESCENCE : raceme, corymb or fascicle. FLOWERS : regular or irregular, usually hermaphrodite. CALYX : sepals 4 or 6 or 8, free or united in one whorl or in two whorls. COROLLA : petals 4, rarely 2 or absent. ANDRŒCIUM : stamens 4 or more. GYNÆCIUM : carpels 2 or more, united in a 1-locular ovary with 2-4 parietal placentas, sometimes the ovary is 2-8-locular. FRUIT : a siliqua (with replum), nut, berry or drupe. SEED : exalbuminous.

DISTRIBUTION : Abundant in the tropical and subtropical regions of the world, especially in Africa.

AFFINITIES : This Order is closely related to the *Cruciferæ* from which it is distinguished by the stamens which are generally indefinite, or which, when only 6 in number, are very rarely tetradynamous, and by the stipitate ovary. Its parietal placentas and disk ally it to the *Resedaceæ*. It has a more distant affinity to the *Bixaceæ*.

PROPERTIES & USES : A few plants possess pungent juice which is dangerous. The root of some plants is said to be very acrid and to blister.

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## CRUCIFERAE* (Dicot ) Fig. 243.
## (C. U. 1912, 1919).

(Words in italics denote *distinguishing characters*).

EXAMPLES : সরিষা (Sarisha, *Brassica Napus* ) ; মূলা (Mula, Radish, *Raphanus sativus*) ; বাঁধাকপি (Cabbage,

*Brassica oleracea*) ; ফুলকপি (Cauliflower which is a variety from Cabbage) ; শালগম (Turnip, *Brassica Rapa*).

FLORAL FORMULA : $K_{2+2}C\times_4A_{2+2}\underline{2}G(\underline{2})$.

**Description.**

HABIT : herbs, annual or perennial, rarely undershrubs ; juice often pungent. LEAVES : *simple, alternate, exstipulate.* INFLORESCENCE : raceme or corymb without bracts and bracteoles. FLOWERS : usually hermaphrodite, regular. CALYX : two-whorled, each whorl bearing 2 free sepals. COROLLA : petals 4 arranged in the form of a cross alternating with the sepals. ANDRŒCIUM : two-whorled ; stamens *tetradynamous*, 2 in the outer whorl and 4 rather longer in the inner whorl, anthers introrse ; nectaries occur at the bases of the stamens. GYNAECIUM : carpels 2 united ; ovary 2-locular by a false septum, called the *replum*, which is an outgrowth from the placentæ ; ovules anatropous and campylotropous. FRUIT : *siliqua* or *silicula*. SEED : *non-endospermous.*

POLLINATION : generally insect-pollinated but self-pollination is also common.

DISTRIBUTION : Abundant in temperate and cold climates, and seldom found otherwise than on mountains in the tropics.

AFFINITIES : This Order is related to the *Papaveraceæ* and *Fumariaceæ*. With the *Capparidaceæ*, the agreement is still closer in the general character of the flower and seed ; but when the Capparidaceæ have so few as six stamens they are not tetradynamous—an almost universal condition in the Cruciferæ.

PROPERTIES & USES : The general character of these plants is antiscorbutic, the watery juice being often pungent and occasionally acrid. The seeds yield oil which is contained in their cotyledons. By cultivation the acrid juices become milder and the structures are easily made very succulent from abnormal development of parenchyma. Under these conditions they become valuable esculents either in their roots, stems, leaf-stalks or undeveloped inflorescence.

**Inter. Questions on "Cruciferae" from 1909-22.**

1. Refer the following plants to their Natural Orders and give reasons for your answer—the Mustard plant, the Melon, the Tulsi plant, the Rice plant (C. U. 1912). Ans: State the *important characteristics* of the following plants—Mustard (*Cruciferae*), Melon (*Cucurbitaceae*), Tulsi (*Labiatae*), Rice (*Gramineae*).

2. Describe the Natural Order *Cruciferae*, with special reference to the leaves. Give examples and drawings to illustrate your description (C. U. 1919).

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*Cohort :* ROSALES.

Flowers cyclic or rarely hemicyclic, monochlamydeous or dichlamydeous, hypogynous or epigynous, regular or zygomorphic; carpels free or united.

Natural Orders : ROSACEÆ, **Leguminosae.**

## Rosaceæ (Dicot.)

(Words in italics denote *distinguishing characters*).

EXAMPLE : গোলাপ (Golap, Rose, *Rosa damascena*).

FLORAL FORMULA : $K_5C_5A_{many}G_1$—many.

**Description.**

HABIT : perennial herbs, shrubs or trees. LEAVES : alternate, simple or compound, usually stipulate, the stipules often attached to the petiole. FLOWERS : generally hermaphrodite, actinomorphic. THALAMUS : generally hollowed to a greater or less extent so that various degrees of perigyny occur. Frequently there is a central protuberance bearing the carpels, even in the forms with very much hollowed thalamus. In a few cases, the carpels are united to the thalamus and are fully inferior. CALYX : sepals 5, imbricate, *odd sepal* posterior. Sometimes an epicalyx is present, which is supposed to be formed from the stipules of the sepals which have become joined in pairs. COROLLA : petals 5, free, imbricate. ANDRŒCIUM : stamens 5 to many, always in whorls, often 10+5+5 ; *incurved in bud.* GYNÆCIUM : carpels 1 to many, *free*, sometimes slightly united at the base ; ovules usually 2 in each carpel, anatropous. FRUIT : often an aggregate

of achenes or drupes or a single drupe or pome. SEED : usually exalbuminous.

DISTRIBUTION : widely distributed.

AFFINITIES : closely related to the *Leguminosæ*. Some are related also to the *Anacardiaceæ*, *Myrtaceæ*, *Calycanthaceæ*, *Saxifragaceæ* and *Ranunculaceæ*.

PROPERTIES & USES : The seeds of some yield hydrocyanic acid. The bark and root of almost all are bitter and astringent. The sap of some contains a gum.

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## LEGUMINOSAE* (Dicot.) Figs. 245, 246. (C. U. 1910, 1913, 1914, 1916, 1919).

(Words in italics denote *distinguishing characters*).

EXAMPLES : ছোলা (Chhola, gram, *Cicer arietinum*) ; মুসুরডাল (Massurdal, *Lens esculenta*) ; মটরসুঁটি (Matarsunti, Pea, *Pisum sativum*) ; কুঁচ্ (Kunch, *Abrus precatorius*) ; অরহরডাল (Arahardal, *Cajanus indicus*) ; মুগেরডাল (Mugerdal, *Phaseolus radiatus*) ; মাস্‌কলাই (Mushkalai, *Phaseolus Roxburghii*) ; বর্‌বাটি (Barbati, *Vigna Catjang*) ; শাঁক আলু (Sankalu, *Pachyrhizus angulatus*) ; সিম (Shim, *Dolichos Lablab*) : অপরাজিতা (Aparajita, *Clitoria Ternatea*) ; মেথি (Methi, *Trigonella Fœnum—græcum*) ; শিশু (Sishu, *Dalbergia Sissoo*) ; নিল (Nil, *Indigofera tinctoria*) ; কাল্‌কাশুন্দ (Kalkashonda, *Cassia occidentalis*) ; কৃষ্ণচূড়া (Krishnachura, *Cæsalpinia pulcherrima*) ; গিলে (Gila, *Entada Pursætha*) ; লজ্জাবতী (Lajjabati, *Mimosa pudica*) ; বাব্‌লা (Babla, *Acacia arabica*) ; শিরিষ (Siris, *Albizzia Lebbek*).

**Description.**

HABIT : trees, shrubs or herbs of most varying habit. The stem is erect, creeping, twining or climbing by tendril or hook. Branches or stipules become usually modified

into thorns. The roots bear small *tubercles* which enable the plants to grow in soils poor in nitrogen. LEAVES : generally *compound*, pinnate, alternate, *stipulate*. INFLORESCENCE : generally simple raceme, sometimes panicle and spike. FLOWERS : regular (and then frequently polygamous) or irregular (and then usually hermaphrodite). CALYX : sepals 5 more or less united, *odd sepal anterior*. COROLLA : petals 5, free. In many cases, the corolla consists of a large posterior petal (vexillum or standard), two smaller side petals (alæ or wings) and the two anterior petals united to form a boat-shaped structure (carina or keel). ANDROECIUM : consists typically of 10 stamens, free or united into a tube ; in the latter case the tenth stamen (the posterior one) often remains free. Many variations from the typical androecium are found. In cases where a keel is present, the stamens are enclosed in it. GYNÆCIUM : *carpel one with edges joined at the posterior side of the flower* with marginal placentation ; ovules usually many. FRUIT : typically a *legume*, but sometimes a lomentum, follicle, pyxis, berry, drupe or nut. SEED : *exalbuminous*, with large fleshy cotyledons containing store of reserve-materials.

This Order is divided into *three* Sub-Orders (*Papilionaceæ*, *Cæsalpinieæ* and *Mimoseæ*) which are distinguished by the following characters :—

(1) PAPILIONACEÆ : Calyx tubular to above the middle ; Corolla papilionaceous with the upper odd petal (standard or vexillum) exterior e.g., মটরশুঁটি (Pea, *Pisum sativum*) ; শিম (Shim, *Dolichos Lablab*) *etc.* (2) CÆSALPINIEÆ : Calyx tubular to below the middle ; corolla with the odd petal inside the lateral one e.g., কৃষ্ণচূড়া (Krishnachura, *Cæsalpinia pulcherrima*). (3) MIMOSEÆ : flowers regular, hypogynous with valvate æstivation ; inflorescence generally a capitulum ; leaves sometimes modified into phyllodes e.g., লজ্জাবতী (Lajjabati, *Mimosa pudica*).

POLLINATION : Pollination is effected by bees which visit these flowers for honey secreted round the base of

the pistil but is wanting in those flowers in which the stamens are all joined. The honey is reached with the help of the free stamen. Stamens and pistil are protected within the keel which is joined to the wings. The insect alights on the wings which are thus pressed down with the keel from which the pistil emerges before the stamens, and catches any pollen-grain that may occur on the body of the insect. *Self-pollination* may sometimes occur.

DISTRIBUTION : The *Papilionaceæ* are universally distributed but are most abundant in warm climates. Some genera are widely diffused, others are almost confined to particular parts of the globe, as Australia, North or South America, Cape of Good Hope etc. The *Cæsalpineæ* and *Mimoseæ* are chiefly tropical but the latter abound beyond this limit in Australia.

AFFINITIES : This Order is closely related to the *Rosaceæ*.

PROPERTIES & USES : Some plants with mild juices are frequently exceedingly nutritious ; when the juices are more concentrated, they become either purgative or astringent. Some of them are poisonous. In other respects, they furnish most valuable timber, fibres, gums, dyes etc. The seeds of many form important food-stuffs.

**Inter. Questions on "Leguminosæ" from 1909-22.**

1. Describe the flower of a member of the Natural Order, *Leguminosæ-papilionaceæ*, indicating particularly how pollination is brought about. (C. U. 1910).

2. Compare the structure of the flower of a Pea with that of a flower of the Sensitive plant and say why they are included in the same Natural Order. (C. U. 1913).

Ans. *Flower of Pea* (*Papilionaceæ*) : flowers zygomorphic ; calyx of five sepals ; corolla of papilionaceous form composed of 5 petals; one large posterior (vexillum or standard), two anterior united into a boat-shaped structure (carina or keel) and two (alæ or wings) on two sides of the keel or carina. Stamens 10 ; filaments all united into a tube surrounding the pistil or the posterior stamen is free. *Flower of Sensitive plant* (*Mimosæ*) : flowers actinomorphic ; calyx & corolla valvate, pentamerous or tetramerous ; stamens free, numerous, or equal or double in number to the petals.

*Reasons why Pea & Sensitive plant are included in the same*

*Natural Order* are (1) that both of them possess *monocarpellary, many-ovuled pistil, and* (2) that both of them possess *alternate, compound and stipulate leaves.*

3. Compare the essential structures which determine a plant as belonging to the Labiatæ and those which determine a plant as Leguminosæ (C U. 1914).

4. Describe briefly the method of pollination of the Garden Pea, illustrating your answer by figures (C. U. 1916).

Ans. See "Pollination" under *Leguminosæ*.

5. Describe the structural characteristics of either the Orchidaceæ or the Leguminosæ (C. U. 1919).

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*Cohort :* GERANIALES.

Flowers cyclic, dichlamydeous or monochlamydeous, rarely achlamydeous, usually pentamerous; stamens variable; carpels 5—2 superior, rarely more, in one whorl, often separated from one another again when ripe; ovules usually 2—1, rarely many.

Natural Orders : **Geraniaceæ,** OXALIDACEÆ, **Rutaceæ, Euphorbiaceæ.**

## GERANIACEAE (Dicot.) Fig. 247.

(Words in italics denote *distinguishing characters*).

FLORAL FORMULA : $K_5C_5A_{5+5}G_{(5)}$.

**Description.**

HABIT : mostly herbs, often hairy. LEAVES : alternate or opposite ; pinnate-veined or palmate-veined, *stipulate.* INFLORESCENCE : a cyme or cymose umbel. FLOWERS : usually regular, hypogynous, hermaphrodite. CALYX : sepals 5, free, imbricate, persistent. COROLLA : petals 5, twisted, clawed, readily falling. ANDRŒCIUM : stamens 10 in two whorls, obdiplostemonous, or inner whorl replaced by staminodes ; slightly joined at the base ; nectaries alternate with the antipetalous stamens. GYNÆCIUM : carpels 5 united, opposite to the petals, seated on a *disc* which grows between them as they ripen ; the styles bearing the stigmatic surfaces are free at the top ; placentation axile with 1 or 2 ovules in each loculus. FRUIT : the *carpels separate*

*when ripe*, and roll back with a strip of the style, which becomes spirally twisted, breaking off from the *carpophore*. The segment of fruit is, in some cases, single-seeded and indehiscent so that the fruit is a true schizocarp ; in other cases, the segment dehisces to set free the seed, and the fruit is called a schizocarpic capsule. SEED : ex-albuminous ; *embryo is curved with folded cotyledons*.

POLLINATION : generally insect-pollinated, sometimes self-pollinated.

DISTRIBUTION : Abundant in the temperate parts of the Northern Hemisphere, Cape of Good Hope and Australia. One species is found in Asia Minor.

AFFINITIES : Many points of affinity exist with *Oxalidaceæ*. *Linaceæ*, *Balsaminaceæ*, *Tropæolaceæ* and *Zygophyllaceæ*. The arrangement of the carpels round a column, the palmate leaves of some kinds, the monadelphous stamens and the convoluted embryo cause a good deal of resemblance to some of the *Malvaceæ* but its imbricated aestivation of Calyx at once distinguishes it from the Malvaceæ.

PROPERTIES & USES : Astringent and aromatic properties are general. Some possess tuberous roots which are eaten at the Cape of Good Hope.

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## OXALIDACEÆ (Dicot.) Fig. 213.

EXAMPLE : আমরুল (Amrul, *Oxalis corniculata*).

FLORAL FORMULA : $K_5C_5A_{5+5}G_{(5)}$.

**Description.**

HABIT : most are perennial herbs. LEAVES : alternate, often compound, exstipulate. INFLORESCENCE : cyme. FLOWERS : large, regular, hermaphrodite. CALYX : sepals 5, free, imbricate, persistent. COROLLA : petals 5, twisted or imbricate, free or slightly united. ANDRŒCIUM : stamens 10 in two whorls, obdiplostemonous, united below with

introrse anthers. GYNÆCIUM : carpels 5 united ; ovary superior, 5-locular, ovules many or few in each loculus ; placentation axile, style free. FRUIT : a capsule or berry. SEED : albuminous.

POLLINATION : Insect—pollinated.

DISTRIBUTION : The members of this Order are generally diffused in temperate and hot climates ; most abundant in America and Cape of Good Hope.

AFFINITIES : Nearly related to the *Geraniaceæ*. From the *Linaceæ* these plants are distinguished by their compound leaves ; but the septa in the capsule of the Linaceæ afford the most constant distinction.

PROPERTIES & USES : The most marked property of this Order is the acid juice, depending on the presence of oxalic acid. Some yield tubers furnishing wholesome food.

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## RUTACEÆ (Dicot.) Fig. 249.

EXAMPLES : পাতিনেবু (Patinebu, Lime, *Citrus acida*) ; বেল (Bael, *Aegle Marmelos*) ; আশ্বাওরা (Ashhoura, *Glycosmis pentaphylla*) ; কামিনি (Kamini, *Murraya exotica*).

FLORAL FORMULA : $K_5$ or $_4C_5$ or $_4A_{10}$ or $_8G_{(5 \text{ or } 4)}$.

**Description.**

HABIT : trees or shrubs, sometimes climbing, rarely herbs. LEAVES : alternate or opposite, exstipulate, usually compound, with glandular dots, often aromatic. INFLORESCENCE : usually cymose. FLOWERS : usually hermaphrodite, rarely unisexual, regular or zygomorphic, with a large *disc* below the gynæcium. CALYX : sepals 5 or 4, free or united, usually imbricate. COROLLA : petals 5 or 4, free, imbricate or valvate. ANDRŒCUIM : stamens 4-5 or 8-10, rarely more, with introrse anthers. GYNÆCIUM : carpels usually 4-5, rarely 3-1 or many, often free at the base and united above by the style ; ovary superior, multilocular ; ovules 2-many in each loculus, anatropous with ventral

raphe and micropyle facing upwards. FRUIT : various, schizocarp, drupe, berry etc. SEED : albuminous or exalbuminous.

DISTRIBUTION : Found chiefly in Europe, North Asia, Cape of Good Hope, Australia and East India.

AFFINITIES : This Order is related to the *Anacardiaceæ* and *Aurantieæ* which differ from this in the character of fruits. There is a considerable affinity to the *Euphorbiaceæ* and some plants belonging to the *Oleaceæ*. There is also some affinity to the *Zygophyllaceæ*, *Ericaceæ* and *Simarubaceæ*.

PROPERTIES & USES : The Rutaceæ are generally remarkable for a strong aromatic odour and for possessing antispasmodic, diuretic and tonic properties. Some fruits are eaten and are generally laxative. Some fruits possess abundant pulp which varies chiefly in the degree of acidity and the peculiar aroma ; the acidity depends, in many cases, on the presence of citric acid which renders them very valuable as antiscorbutic agents.

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## EUPHORBIACEÆ* (Dicot.) Figs. 250, 251.

(Words in italics denote *distinguishing characters*).

EXAMPLE : ভেরাণ্ডা (Bherenda, Castor, *Ricinus communis*).

**Description.**

HABIT : shrubs or trees, a few herbs, most contain a milky juice which is often poisonous. LEAVES : simple, rarely compound, usually alternate but sometimes opposite above and alternate below ; stipules usually present but may be represented by branched hair-like structures, glands or thorns. INFLORESCENCE : usually complex, often the first branching is racemose and all subsequent ones cymose. FLOWERS : *unisexual*, monoecious or dioecious, regular, hypogynous. PERIANTH : usually absent, sometimes one whorl (Calyx) of 5 parts is present, or rarely two whorls, each of 5 parts, are present. ANDROECIUM : stamens,

1 to many, free or united in various ways ; *Ricinus* has branched stamens. GYNÆCIUM : carpels 3 usually united ; ovary superior with axile placentation and 3 loculi ; ovules 1 or 2 in each loculus. FRUIT : invariably a *schizocarp-capsule separating into cocci.* SEED : *albuminous with a characteristic caruncle.*

DISTRIBUTION : Widely distributed over the globe.

AFFINITIES : This Order is closely related to the *Sterculiaceæ* and *Malvaceæ* as the composition of ovary is analogous and the stamens often monadelphous. Some are related to the *Rhamnaceæ*. They approach the *Urticaceæ* owing to the possession of unisexual and frequently incomplete flowers but they differ from the Urticaceæ by their compound ovaries.

PROPERTIES & USES : These plants very frequently produce a juice which contains caoutchouc ; the watery part of this sap is generally more or less acrid, purgative, emetic or powerfully poisonous, from the presence of a principle dissipated by heat ; starch abounds in the roots of some kinds, while oil of a purgative character is common in the seeds ; the bark of some of the trees has tonic properties ; the wood of several is very valuable for its hard close texture ; and several of the plants furnish dyes.

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*Cohort :* SAPINDALES.

Flowers cyclic, monochlamydeous, dichlamydeous or achlamydeous, usually pentamerous ; androecium various ; gynaecium of 5—2 united carpels, rarely more, often separated from one another again when ripe, usually with 2—1, rarely many, ovules which are either pendulous with dorsal raphe and micropyle facing upwards, or ascending with ventral raphe and micropyle facing downwards.

Natural Orders : **Anacardiaceæ,** SAPINDACEÆ.

## ANACARDIACEÆ (Dicot.) Figs. 252, 253.

EXAMPLES : আম (Am, Mango, *Mangifera indica*) ; আম্‌রা (Amra, *Spondias Mangifera*).

**Description.**

HABIT : trees or shrubs, often with a resinous or milky acrid-juice. LEAVES : simple or compound, usually alternate, very rarely opposite, without gland-dots. INFLORESCENCE : usually a panicle. FLOWERS : small, usually regular and hermaphrodite, sometimes polygamous or unisexual. CALYX : sepals small, usually with 5, sometimes 3-4 or 7 lobes, persistent. COROLLA : petals equal in number to the lobes of the calyx or absent. ANDRŒCIUM : stamens as many as petals, rarely more, inserted on an annular fleshy *disc* ; anthers, 2-celled. GYNÆCIUM : carpels usually 3 free or united, very often only one of the three is fertile, and frequently only one carpel is found at all ; sometimes there are 5 or 6 carpels ; ovary superior, rarely inferior, 1-locular ; ovule solitary on a long funicle. FRUIT : indehiscent, commonly drupaceous. SEED : exalbuminous or albumen very scanty.

DISTRIBUTION : Chiefly tropical.

AFFINITIES : This Order is related to the *Xanthoxyleæ*, *Burseraceæ*, *Connaraceæ*, *Rosaceæ* and *Leguminosæ* but differs in the structure of the ovary and seed.

PROPERTIES & USES : The resinous juice of these plants is acrid or violently irritating or poisonous. Some kinds, however, yield edible fruits. Some are powerful purgative and emetic. The bark of some is used in tanning and the wood of a few yields dye.

## SAPINDACEÆ (Dicot.)

EXAMPLES : লিচু (Litchi, *Nephelium Litchi*) ; আশফল (Ashphal, *Nephelium Longana*) ; রিটা (Ritha, *Sapindus Mukorossi*).

**Description.**

HABIT : trees or shrubs, rarely undershrubs or herbs, sometimes climbing or twining, occasionally with tendrils. LEAVES : simple or compound, alternate or opposite. INFLORESCENCE : cymose, usually scorpioid cyme with bracts and bracteoles. FLOWERS : unisexual, generally monœcious or polygamous, regular or irregular, small. CALYX : sepals 4-5, free or united. COROLLA : petals usually 5, sometimes 4, occasionally absent. ANDRŒCIUM : 5-10, often with 2 absent, more rarely 5, 4 or many, inserted within or rarely upon the *disc* round the rudimentary ovary. GYNÆCIUM : carpels usually 3, united ; ovary usually 3-locular with terminal style ; ovules 1-2, rarely more, in each loculus. FRUIT : a capsule, nut, berry, drupe, schizocarp or samara. SEED : often arillate, exalbuminous.

DISTRIBUTION : Natives of the tropics, especially of South America and India ; some occur in North America and other temperate regions.

AFFINITIES : These plants are distinguished from the *Malpighiaceæ* by their asymmetrical flowers.

PROPERTIES & USES : Some produce delicious fruits. The bark of some is astringent and is used in dyeing. The sap of a few plants yields sugar in the spring. The fruits of some make a lather with water and are used for washing. The juice of the leaves and bark of some species is poisonous. Some yield light and handsome timber.

*Cohort :* RHAMNALES.

Flowers regular, cyclic, sometimes apetalous ; stamens opposite to petals ; carpels 5—2 united ; ovules 1—2 ascending with dorsal, lateral or ventral raphe.

Natural Orders ; VITACEÆ, RHAMNACEÆ.

## VITACEÆ or AMPELIDEÆ (Dicot.) Fig. 254.

EXAMPLES : আঙ্গুর (Vine, *Vitis vinifera*) ; হারজোরা (Harjora, *Vitis quadrangularis*).

**Description.**

HABIT : shrubs, climbing by tendrils, less often erect. LEAVES : alternate, stipulate, frequently gland-dotted. INFLORESCENCE : cymose, usually complex ; bracteoles present. FLOWERS : small, regular, hermaphrodite or unisexual. CALYX : sepals 4-5, small and cup-like, very slightly lobed. COROLLA : petals 4-5, valvate, often united at the tips and falling off as a hood on the opening of the bud. ANDRŒCIUM : stamens 4-5, opposite to the petals, at the base of a hypogynous *disc*, with introrse anthers. GYNÆCIUM : carpels usually 2 united, rarely 3-6 ; ovary multilocular with 2 anatropous ovules in each loculus. FRUIT : berry. SEED : albuminous.

DISTRIBUTION : Mostly natives of tropical and sub-tropical regions.

AFFINITIES : Some plants are related to the *Meliaceæ*, *Celastrineæ*, *Rhamnaceæ*, and *Araliaceæ*.

PROPERTIES & USES : The plants of this Order generally produce delicious fruits.

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## RHAMNACEÆ (Dicot.) Fig. 256.

EXAMPLE : কুল (Kul, *Zizyphus Jujuba*).

**Description.**

**Habit** : nearly all are trees or shrubs, often climbing by aid of hooks, tendrils and twining stems. **Leaves** : simple, usually stipulate, leathery, never lobed or divided. **Inflorescence** : cymose, or a corymb. **Flowers** : small, hermaphrodite, rarely unisexual, regular, sometimes apetalous. **Thalamus** : hollow, free from or united to the ovary. **Calyx** : Sepals 5-4, valvate. **Corolla** : petals 5-4, rarely absent, inserted on the throat of the calyx-tube, clawed. **Androecium** : stamens 5-4, opposite and attached to the petals, often hidden within them ; *disc* usually well-developed, intra-staminal. **Gynaecium** : carpels free or more or less united to thalamus ; ovary 3—, rarely 2-or 4-locular ; ovules 1, rarely 2, in each loculus, erect, anatropous, the raphe dorsal, rarely lateral. **Fruit** : dry, splitting into dehiscent or indehiscent mericarps, or a drupe or a nut. **Seed** : albumen small or absent.

**Distribution** : Widely distributed.

**Affinities** : The *Rhamnaceae* are clearly distinguished from the *Celastraceae* by the position of the stamens before the petals. The position of their stamens, the fleshy disc and the separate petals indicate great difference from the Order, *Aquifoliaceae*. Their nearest relations are the *Byttneriaceae* and *Euphorbiaceae*.

**Properties & Uses** : Some are acrid and purgative, some are tonic, others with edible fruits. Some fruits yield dyeing material.

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*Cohort* : **Malvales**.

Flowers cyclic but not always, rarely apetalous ; hermaphrodite, rarely unisexual, usually regular ; Calyx and Corolla usually pentam-

erous ; Calyx usually valvate ; stamens many or in 2 whorls with the inner divided ; carpels 2 to many, each with 1 to many anatropous ovules.

Natural Orders : **Tiliaceae, Malvaceae, Sterculiaceae.**

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## TILIACEAE (Dicot.) Fig. 255.

**Example :** পাট (Pat, Jute, *Corchorus capsularis*).

### Description.

**Habit** : trees or shrubs, rarely herbs. **Leaves** : simple, alternate, rarely opposite, usually stipulate. **Inflorescence** : always, at least after the first branching, cymose and often very complex. **Flowers** : usually hermaphrodite, regular ; *disc* annular or absent. **Calyx** : sepals 5, free or united, valvate. **Corolla** : petals 5 free, rarely absent, often glandular at base. **Androecium** : stamens usually many, free or united in groups, inserted at base of petals or on androphore, with 2-celled anthers. **Gynaecium** ; carpels 2 to many ; ovary superior, 2—to many—locular, with 1 to many ovules in each loculus. **Fruit** : fleshy or dry, indehiscent or dehiscent. **Seed** : albuminous.

**Distribution** : Some of these plants occur in the northern parts of both hemispheres, the rest are chiefly tropical.

**Affinities** : The distinct or polyadelphous stamens, the 2-locular anthers, and the disc separate these plants from their near allies, the *Malvaceae* and *Sterculiaceae*. From *Ternstroemiacae* they differ in the aestivation of the Calyx, and from *Bixaceae* in the structure of the fr uit.

**Properties & Uses :** These plants generally possess mucilaginous juices and fibrous bark. Many are valuable timber-trees and some yield edible fruits. A few of these plants yield a dye.

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## MALVACEAE * (Dicot.) Fig. 257.
## (C. U. 1911, 1917, 1922).

(Words in italics denote *distinguishing characters*).

**Examples :** জবা (Jaba, *Hibiscus Rosa-sinensis*); ঢাঁরস (Dhanras, *Hibiscus esculentus*); স্থলপদ্ম (Sthalpadma, *Hibiscus mutabilis*); পলাস (Palas, *Thespesia populnea*); সিমূলতুলা (Simul Cotton, *Bombax malabaricum*); কাপাসতুলা (Kapas Cotton, *Gossypium acuminatum*).

**Floral Formula :** $K_{(5)}\ C_{(5)}\ A_{many}\ G_{\underline{(5)\ to\ many.}}$

### Description.

**Habit :** herbs, shrubs or trees. **Leaves :** simple, alternate, *palmate-veined*, *stipulate*. **Inflorescence :** sometimes compound, made up of scorpioid cymes. **Flowers :** usually regular, hermaphrodite, hypogynous. **Calyx :** sepals 5 slightly *united* or free, persistent, *valvate*, some possess an *epicalyx* probably formed of bracteoles. **Corolla :** petals 5 free, slightly joined at the base with the staminal tube, *twisted* in the bud. **Androecium :** stamens usually many owing to branching, *all united below into a tube* which is joined to the petals and at first sight makes the Corolla appear gamopetalous ; *each anther =half an anther, reniform*, the pollen grains are spiny.

**Gynaecium :** Carpels 1 to many frequently 5, united ; ovary superior, multilocular, placentation axile ; ovules 1 to many in each carpel, anatropous, usually ascending, sometimes pendulous. **Fruit :** generally a dry capsule or schizocarp, sometimes a berry. **Seed** : albuminous ; *embryo curved with twisted cotyledons.*

**Pollination :** Mostly insect-pollinated. Self-pollination takes place in forms with less conspicuous flowers by the tips of the styles, bearing the stigmas, turning back to pick up the pollen grain.

**Distribution :** Natives of tropics and warm temperate regions.

**Affinities :** The Malvaceae are closely allied to the *Sterculiaceae* and *Tiliaceae* by the general structure and the aestivation of the Calyx but are distinguished by their 1-locular anthers ; to the *Geraniaceae* they are related by their monadelphous anthers and twisted aestivation of the Corolla.

**Properties & Uses :** The most important qualities of these plants depend upon their tissues, namely the fibrous bast of their stems, which, in some cases, furnishes large quantities of hemp-like fibre to commerce. The leaves of some plants yield a blue dye like indigo. The seeds of Cotton contain a large quantity of almost colourless oil.

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## STERCULIACEAE (Dicot.)

**Example :** কনকচাঁপা (Kanak Champa, *Pterospermum acerifolium*).

### Description.

**Habit :** trees, shrubs or herbs ; some are lianes. **Leaves :** alternate, usually stipulate. **Inflorescence :** usually

a complex cyme. **Flowers** : usually regular and hermaphrodite, sometimes unisexual. **Calyx** : sepals 5 usually united below, valvate, with no epicalyx. **Corolla** : petals 5 or absent, free or sometimes attached below to staminal column. **Androecium** : stamens many, often branched, more or less united into a tube ; anthers 2-celled. **Gynæcium** : carpels usually 2-5 united, rarely solitary ; ovary superior, sessile or stalked, usually 2-5-locular ; ovules 2 to many in each loculus, anatropous. **Fruit** : various, often a schizocarp. **Seed** : usually albuminous, sometimes arillate.

**Distribution** : Mostly tropical or sub-tropical.

**Affinities** : Related to the *Malvaceae* and *Tiliaceæ*.

**Properties & Uses** : Generally mucilaginous. The seeds of some are oily. Some species yield fibres fit for cordage and woven fabrics.

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*Cohort* : **Parietales.**

Flowers cyclic or hemicyclic with often many stamens and carpels, dichlamydeous, rarely apetalous, hypogynous or epigynous, carpels free or united, often with parietal placentation.

Natural Orders : **Passifloraceae, Begoniaceae.**

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## PASSIFLORACEAE (Dicot.)

**Example** : পেঁপে (Papaya, *Carica Papaya*.)

### Description.

**Habit** : herbs or shrubs, mostly climbers with axillary tendrils. **Leaves** : alternate, often stipulate. **Inflorescence** : usually a panicle. **Flowers** : regular, hermaphro-

dite or unisexual, monoecious or dioecious. **Thalamus :** of various shapes, often hollowed and frequently with a central andro-or gyno-phore ; it is usually terminated by outgrowths, often of petaloid or staminodial appearance, forming the *corona*. **Calyx :** sepals 3-5, united. **Corolla :** petals 3-5, usually united. **Androecium :** stamens 3-5 attached to the calyx ; anthers usually 1-celled, sometimes 2-celled. **Gynaecium :** carpels usually 3, united ; ovary generally 1-locular ; ovules many, anatropo us ; placentation axile. **Fruit :** a capsule or berry. **Seed :** albuminous with fleshy aril.

**Distribution :** Mostly tropical or sub-tropical. Some occur in South America and West India. A few occur in North America, Africa, East Indies and Australia.

**Affinities :** This Order is generally associated with the *Cucurbitaceæ* which it resembles in habit and structure of the ovary, the most marked difference being the hermaphrodite flower, superior ovary and the albumen in the seed. The corona and the gynandrophore mark this Order out very clearly. It is closely allied to the *Samydaceæ* in which, however, there is no corona. Its relations to the *Capparidaceae*, *Bixaceae* and *Violaceae* are also well marked.

**Properties & Uses :** The pulpy fruits of many species are eaten. Astringent properties occur in the leaves and some leaves are said to be narcotic.

---

## BEGONIACEAE (Dicot.)

### Description.

**Habit** : most are perennial herbs with thick rhizomes or tubers, a few are undershrubs or climbers by roots. **Leaves**: generally alternate, asymmetrical with large stipules. **Inflorescence** : like dichasial cyme. **Flowers** : asymmetrical, unisexual, monoecious. **Perianth** : in *male* flower, 2-whorled, outer whorl usually contains 2 parts and the inner whorl usually 2, sometimes absent ; in *female* flower, the perianth consists of 2-6 parts. **Andrœcium** : stamens usually many, free or united ; anthers 2-celled. **Gynæcium** : carpels usually 2-3 with 2-3 loculi ; ovary inferior with many anatropous ovules ; placentation axile, often projecting far into the ovary. **Fruit** : usually capsular. **Seed** : exalbuminous.

**Distribution** : Natives chiefly of India, South America and the West Indies.

**Affinities** : Nearly related to the *Cucurbitaceae*.

**Properties and Uses** : The roots of many plants appear to be bitter and astringent, sometimes purgative.

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*Cohort* : **Opuntiales.**

Flowers hemicyclic, dichlamydeous with many spirally arranged stamens and parts of perianth, carpels 4 to many, forming an inferior ovary.

Natural Order : **Cactaceæ.**

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## CACTACEÆ (Dicot.)

**Example :** নাগফণা (Naghphana, *Opuntia dillenii*)

### Description.

**Habit :** fleshy, mostly leafless plants of peculiar aspect, with stems globular or columnar and many-angled, or flattened and jointed, usually with prickles which are regarded by some as modified leaves and by others as emergences. **Flowers:** usually regular, hermaphrodite, solitary. **Perianth :** leaves usually many, showing gradual transition from sepaloid to petaloid leaves, spirally arranged, often up to the side of the ovary. **Androecium :** stamens many, epipetalous. **Gynæcium :** carpels 4 to many ; ovary inferior, unilocular with many anatropous ovules ; placentation parietal. **Fruit :** a berry, the flesh being derived from the funicles. **Seed :** albumen scanty or absent

**Distribution :** Almost exclusively found in the hotter parts of America, especially in dry situations. One species is found in Africa and Ceylon.

**Affinities :** This Order is closely related to the *Loasaceae*. There is also considerable resemblance to the *Mesembryanthaceae*, *Cucurbitaceae*, *Saxifragaceae* and *Ribesiaceæ*.

**Properties & Uses :** A subacid juice is commonly present in these plants, whence some of them are esteemed as remedies in fevers.

—o—

*Cohort* : **Myrtiflorae.**

Flowers cyclic, dichlamydeous, rarely apetalous, usually regular; axis tubular; carpels 2 to many, usually united to axis, rarely free.

Natural Orders : **Lythraceae, Combretaceae, Myrtaceae.**

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## LYTHRACEAE (Dicot).

**Examples** : ডালিম (Dalim, Pomegranate, *Punica Granatum*) ; কেওরা (Keora, *Sonneratia apetala*); মেঁথী ( Menthi, *Lawsonia alba*).

### Description.

**Habit** : herbs, shrubs or trees. **Leaves** : usually opposite, simple, entire. **Inflorescence** : raceme, panicle or dichasial cyme. **Flowers** : regular or zygomorphic, usually hermaphrodite. **Calyx** : sepals usually 2-6, united, valvate ; frequently an epicalyx, formed of stipules, is present ; the axis ("calyx-tube") is hollow, generally tubular ; **Corolla** : petals as many as sepals, crumpled in bud, sometimes absent. **Andrœcium** : stamens inserted on calyx-tube, typically twice as many as sepals but sometimes fewer or many. **Gynaecium** : ovary superior, usually 2-6-locular, rarely 1- locular ; ovules usually many, anatropous, ascending ; style simple ; stigma capitate. **Fruit** : dry, usually capsular. **Seed** : exalbuminous.

**Distribution** : Found in all zones excepting the frigid.

**Affinities** : This Order is nearly related to the *Saxifragaceae*. It is also related, to a certain extent, to the *Labiatae*, several *Calycifloral Orders* and *Rhizophoreae*.

**Properties & Uses :** Many of these plants have astringent properties and several are valuable as dyes. A few possess blistering properties.

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## COMBRETACEAE (Dicot.)

**Example :** হরিতকী (Haritaki, Myrobalan, *Terminalia citrina*)

### Description.

**Habit :** trees and shrubs, many are climbers, some twining and some with hooks formed of the persistent bases of the petioles. **Leaves :** alternate or opposite, simple, exstipulate. **Inflorescence :** generally racemose, rarely cymose. **Flowers :** usually hermaphrodite, regular and sessile. **Calyx :** sepals 4-5, united, usually valvate, persistent or deciduous **Corolla :** petals 4-5 or absent. **Androecium :** stamens usually 10, sometimes 5 or 15, rarely many. **Gynaecium :** ovary inferior, 1—locular with 2-5 anatropous, pendulous ovules. **Fruit :** dry, 1—seeded, often winged at the angles. **Seed :** exalbuminous ; cotyledons convolute.

**Distribution :** Generally distributed throughout the tropics.

**Affinities :** This Order is closely related to the *Myrtaceae*. It is also related to the *Onagraceae, Rhizophoraceae, Santalaceae* and *Lauraceae.*

**Properties & Uses :** The bark of some plants is astringent and is used in tanning. Some seeds are eaten like almonds. Many yield valuable timber-trees.

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## MYRTACEAE (Dicot) Fig. 258.

**Examples :** পেয়ারা (Piyara, Guava, *Psidium Guyava*) ; কালজাম (Kalajamb, *Eugenia Jambolana*) ; গোলাপজাম (Golap-jamb, *Eugenia Jambos*) ; লবঙ্গ (Labanga, *Caryophyllus aromaticus.*)

### Description.

**Habit :** trees or shrubs, varying in size from a small creeper to a giant tree, sometimes herbs. **Leaves :** opposite, rarely alternate or whorled, entire, usually gland-dotted with a submarginal vein. **Inflorescence :** generally a cyme. **Flowers :** usually hermaphrodite, regular ; the receptacle is more or less hollow and united to the ovary. **Calyx :** usually 4-5, united or free, valvate or imbricate, sometimes falling off like a cap. **Corolla :** petals usually 4-5, rarely 6 or fewer by abortion, or absent. **Andrœcium :** stamens usually 8-10 or numerous, rarely 4-5, distinct or polyadelphous. **Gynaecium :** ovary inferior or half inferior, 1—to many-locular with 2 to many anatropous or campylotropous ovules in each loculus ; placentation usually axile, rarely parietal. **Fruit :** a berry, drupe, capsule or nut. **Seed :** exalbuminous.

**Distribution :** Mainly distributed throughout tropical and subtropical climates.

**Affinities :** This Order is nearly related to the *Rosaceae*, *Melastomaceae*, *Lythraceae* and *Onagraceae*. There is some relation to the *Lecythidaceae* and *Chamaelauciaceae*.

**Properties & Uses :** Some of these plants are aromatic, some are astringent and others yield gum or saccharine juices. Some plants produce excellent fruits.

*Cohort* : **Umbellifloræ.**

Flowers cyclic, dichlamydeous, epigynous, 5-4-merous rarely many-merous, usually hermaphrodite, regular; carpels (5-1) or (many) united, each with 1, rarely 2, pendulous anatropous ovules with 1 integument; endosperm copious; flowers usually in umbels.

Natural Order : **Umbelliferae.**

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## UMBELLIFERAE (Dicot.) Figs. 259, 260.

**Examples** : জোয়ান (Jowan, *Carum copticum*) ; ধনে (Dhane, *Coriandrum sativum)* ; গাজর (Gajar, Carrot, *Daucus Carota*) ; মউরি (Mowri, *Foeniculum vulgare*).

### Description.

**Habit** : herbs with stout stems whose internodes are hollow, rarely shrubs or trees. **Leaves** : alternate, sheathing at the base and generally deeply divided. **Inflorescence** : usually a compound umbel. **Flowers** : usually hermaphrodite, regular ; the tube of the receptacle is sometimes adherent to the ovary. **Calyx** : sepals 5, usually very small, the odd sepal posterior. **Corolla** : petals 5, rarely absent, springing from the *disc* crowning the ovary. **Androecium** : stamens 5 springing from the disc crowning the ovary, incurved in the bud. **Gynæcium** : carpels 2 united into an inferior ovary surmounted by a double fleshy disc or stylopod from which project 2 divergent styles ; ovules 1 in each loculus, pendulous. **Fruit** : a cremocarp which splits down the septum between the carpels into 2 mericarps, each containing one seed and joined to a forked carpophore. **Seed** : albuminous, albumen cartilaginous.

**Distribution** : Abundant in the northern and central parts of Europe, Asia and America ; common upon the mountains of warmer regions, and again met with in the Southern hemisphere, but chiefly as dwarf and aberrant forms.

**Affinities** : The relations of the Umbelliferae are closest with the *Araliaceae* (from which their fruit differs), *Rubiaceae* (which have gamopetalous corollas, opposite leaves and interpetiolar stipules) and *Cornaceae* (where the leaves are partly opposite, the flowers tetramerous and the fruit succulent). In habit as well as in bicarpellary structure, some of the Umbelliferae approach the *Saxifragaceae*.

**Properties & Uses** : Many plants possess narcotic poisonous substances in solution in the watery juices ; the juice of some possesses a gum-resinous matter which becomes milky on exposure to the air ; others possess aromatic oils especially developed in the pericarp. The root, stem and petiole of some, when rendered very succulent by cultivation, retain only a moderate quantity of aromatic oils, and are then chiefly valuable for their saccharine and mucilaginous qualities.

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*Cohort* : **Ebenales.**

Petals united, stamens rarely many, ovary multi-locular with axile placentation, and one or few ovules in each loculus.

Natural Order : **Sapotaceae.**

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# SAPOTACEAE (Dicot.)

**Examples** : বকুল (Bakul, *Mimusops Elengi*) ; মোহা (Moha *Bassia latifolia*).

## Description.

**Habit** : trees or shrubs, mostly with a milky juice. **Leaves** : entire, leathery, sometimes stipulate. **Flowers** : solitary or in cymose bunches, bracts present or absent, hermaphrodite, regular. **Calyx** : sepals 4-8, free, persistent. **Corolla** : petals usually equal in number to sepals, more or less united. **Androœcium** : stamens attached to the corolla-tube, as many as and opposite to the corolla-lobes, arranged in 2 or 3 whorls but frequently the outer ones are staminodial or absent ; anthers commonly extrorse. **Gynæcium** : carpels united in a superior, 2-8-locular ovary ; ovules solitary in each loculus, anatropous ; placentation axile. **Fruit** : a berry. **Seed** : few or one, usually albuminous, albumen oily.

**Distribution** : Abundant in the tropics of both hemispheres.

**Affinities** : Allied to the *Myrsinaceae* and *Ebenaceae*.

**Properties & Uses** : The plants of this Order are valuable for succulent fruits, febrifuge bark, oleaginous secretions and peculiar gum-resins in the milky juices. The dried flowers of *Bassia latifolia* are full of saccharine matter and are used as food in some parts of India under the name of Mowah. The fruits and seeds of some yield a valuable oil.

*Cohort* : **Contortae.**

Flowers usually 5—, rarely 2-6-merous, usually gamopetalous; stamens usually as many as petals, sometimes fewer, rarely hypogynous, usually united at base to corolla ; carpels 2 united ; corolla usually convolute, sometimes valvate ; leaves usually opposite, undivided and exstipulate.

Natural Orders : **Apocynaceae, Asclepiadaceae.**

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## APOCYNACEAE (Dicot). Fig. 261.

**Examples** : করমচা (Karamcha, *Carissa Carandas*) ; কনকে (Koalka, *Thevetia neriifolia*) ; কোরবী (Korabi), *Nerium odorum*) ; গন্ধমালতী (Gandhamalati, *Aganosma caryophyllata*)

### Description.

**Habit** : shrubs twining or erect, rarely trees ; latex is always present. **Leaves** : opposite or whorled, rarely alternate, entire. **Inflorescence** : primary type is a panicle, but in its later branchings it sometimes goes over into a dichasial-cyme or a cincinnus ; bracts and bracteoles are both present. **Flowers** : hermaphrodite, regular. **Calyx** : sepals 5, rarely 4, united. **Corolla** : petals 5, rarely 4, united, usually salver-or funnel-shaped, often hairy within, generally convolute. **Androecium** : stamens 5, rarely 4, epipetalous, with short inc uded filaments. **Disc** : usually present. **Gynaecium** . carpels usually 2 united or united by style and free in the ovarian region, rarely more, superior, 1-or 2- locular when syncarpous ; ovules in each carpel 2 or many, very rarely solitary. **Fruit** : usually of 2 follicles, sometimes a drupe or berry. **Seed** : usually winged and often with a crown of hairs serving for wind distribution.

**Distribution** : Chiefly tropical, a few scattered in temperate climates.

**Affinities** : Related closely to some *Loganiaceae* and *Gentianaceae*, also to the *Asclepiadaceae* from which they are chiefly distinguished by the freedom of stamens from the stigma and by the granular pollen.

**Properties & Uses** : Often violent poisons, acting as drastic purgatives and emetics, sometimes with a narcotic influence. Not a few, however, have delicious edible fruits. The bark of some is tonic and febrifuge. The poisonous principles appear to occur chiefly in the seeds and milky juice.

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## ASCLEPIADACEAE* (Dicot) Fig. 262 (C.U.1922).

**Examples** : আকন্দ (Akanda, *Calotropis gigantea*) ; অনন্তমূল (Anantamul, *Hemidesmus indicus*).

### Description.

**Habit** : herbs or shrubs, usually twining, latex is present. **Leaves** : simple, entire, usually opposite. **Inflorescene** : cymose or recemose (raceme or umbel). **Flowers** : regular, hermaphrodite. **Calyx** : sepals 5, more or less united, imbricate. **Corolla** : petals 5, more or less united, convolute or valvate. **Androecium** : stamens 5, epipetalous ; filaments united into a tube and often prolonged beyond and behind the anther into horn-like processes constituting the corona ; anthers 2-celled, each cell contains granular or waxy masses (*pollinia*) of pollen, the pollinia being united in pairs or fours to a gland (*corpusculum*) on the 5-angled fleshy stigma. **Gynaecium** : carpels 2, superior, free

below but united at the tip with a common style, enclosed within the staminal column ; ovules usually many. **Fruit :** of 2 follicles. **Seed :** usually crowned by a tuft of hairs for wind-carriage ; albumen cartilaginous, slight.

**Distribution :** Mostly tropical, abundant in Asia, Africa and America. One or two species occur in Europe and a few in North America.

**Affinity :** This Order is closely related to the *Apocynaceae*.

**Properties & Uses :** The properties are generally similar to those of the Apocynaceae but are not so active.

———o———

*Cohort* : **Tubiflorae.**

Flowers typically with 4 isomerous whorls, or more often with reduction in gynæcium, or if zygomorphic, also in andrœcium ; stamens epipetalous ; ovule with 1 integument.

Natural Orders : **Convolvulaceae, Boraginaceae, Verbenaceae, Labiatae, Solanaceae, Scrophulariaceae, Bignoniaceae, Acanthaceae.**

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## CONVOLVULACEAE (Dicot.) Fig. 263.

**Examples :** ভূঁইকুমড়া (Bhuikumra, *Ipomoea paniculata*) ; শাকরকন্দ আলু (Shakarkandalu, *Ipomoea Batatas*); কলমীশাক (Kalmishak, *Ipomoea reptans*).

**Floral Formula :** $K_{(5)}\ \overbrace{C_{(5)}\ A_5}\ G_{(2)}$

**Description.**

**Habit :** herbs or shrubs, usually twining, rarely erect, very rarely trees ; sometimes parasitic. **Leaves :** alternate

or in parasitic species absent. **Inflorescence** : dichasial cyme with tendency to become scorpioid or helicoid cyme ; bracts and bracteoles present. **Flowers** : hermaphrodite, regular. **Calyx** : sepals 5, imbricate, occasionally slightly united at base, often persistent. **Corolla** : petals 5, united **Androecium** : stamens 5, alternating with petals, epipetalous ; anthers usually introrse. **Gynæcium** : carpels, usually 2, rarely 3-5, united ; ovary on a honey—secreting disc ; ovules 2, rarely 4, in each loculus, usually anatropous ; placentation axile. **Fruit** : berry, nut or capsule. **Seed** : albuminous.

**Pollination** : Insec—tpollinated.

**Distribution** : Mainly tropical, a few species occur in temperate climates.

**Affinities** : This Order approaches the *Boraginaceae*, *Polemoniaceae* and allied Orders ; the structure of the ovary separates it from the first, and the fruits from the second.

**Properties & Uses** : A purgative property generally characterises these plants among which are several yielding important medicinal properties. Some produce fleshy tuber and root which are eaten.

———o———

## BORAGINACEAE (Dicot.) Fig. 264.

**Example** : হাতিশুরা (Hatisura, *Heliotropium indicum*)

**Floral Formula** : $K_{(5)}\ \overset{\frown}{C_{(5)}\ A_5}\ G_{\underline{(2)}}$

**Description.**

**Habit** : most are herbs, a few shrubs and trees. **Leaves** : usually alternate ; leaves and the rest of the plant are gener-

ally covered with stout hairs. **Inflorescence**: usually a scorpioid cyme. **Flowers**: hermaphrodite usually regular. **Calyx**: sepals usually 5 united, usually persistent, imbricate or open in bud. **Corolla**: petals usually 5 united, funnel-shaped or tubular. **Andrœcium**: stamens 5, epipetalous, alternate with petals; anthers introrse. **Gynæcium**: carpels usually 2 on hypogynous disc; ovary superior, usually 4-locular by false septum; ovule 1 in each loculus, erect, anatropous; style usually gynobasic. **Fruit**: a drupe or 4 achenes. **Seed**: generally albuminous.

**Distribution**: Mostly natives of temperate climates in the northern hemisphere.

**Affinities**: The 4—lobed ovary and fruit of this Order agree exactly with those of the *Labiatae*, in which the irregular corolla, didynamous stamens, opposite leaves and square stems differ widely. It is also related to the *Ehretieae*.

**Properties & Uses**: Generally mucilaginous and cooling, the latter property being due to the potassium nitrate they contain. Some yield dye and the fruits of others are eaten.

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## VERBENACEÆ (Dicot.) Figs. 265, 266.

**Examples**: ভাঁট (Bhant, *Clerodendron infortunatum*); সেগুন (Shegun, *Tectona grandis*).

### Description.

**Habit**: herbs, shrubs or trees. **Leaves**: usually opposite, rarely alternate or whorled. **Inflorescence**: racemose or cymose; in the former case, it is most often a

spike or head, often with an involucre of coloured bracts ; the cymes are usually dichasia, sometimes they also form heads. **Flowers** : usually hermaphrodite, zygomorphic. **Calyx** : sepals usually 5 or 4, very rarely 6-8, united, persistent. **Corolla** : petals 5 united, usually with narrow tube, often 2-lipped. **Andrœcium** : stamens 4 didynamous, rarely 5 or 2 or of equal length, alternate with corolla lobes ; anthers introrse. **Gynæcium** : carpels usually 2, rarely 4 or 5, united ; ovary superior, usually 4-lobed ; ovule 1 in each loculus ; placentation axile ; style usually terminal, rarely more or less sunk between the lobes of the ovary. **Fruit** : generally a drupe, more rarely a capsule or schizocarp. **Seed** : usually exalbuminous.

**Distribution** : Chiefly tropical.

**Affinities** : The arrangement of the parts of the flower of this Order is like that of the *Scrophulariaceae* but the structure of the fruit is different. It is principally distinguished from the *Labiatae* by the terminal style and more coherent carpels.

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## LABIATAE (Dicot.) Fig. 267. (C. U. 1910, 1912, 1914).

**Examples** : তুলসী (Tulsi, *Ocimum sanctum*) ; পাথরচুর (Pathurchur, *Coleus aromaticus*).

**Floral Formula** : K $\overset{\frown}{(5)}$ C $\overset{\frown}{(5)}$ A 4 G $\underline{(2)}$.

### Description.

**Habit** : mostly herbs or undershrubs with usually 4-angled stems. **Leaves** : opposite or whorled, often hairy

and gland-dotted. **Inflorescence** : generally a verticillaster. **Flowers** : hermaphrodite, zygomorphic. **Calyx** : sepals united into 4-5 cleft or distinctly 2 lipped calyx which is persistent. **Corolla** . petals 5 united into usually 2-lipped corolla, sometimes corolla is 4-5 lobed. **Androecium** : petals 4 didynamous or only 2 perfect, epipetalous ; anthers introrse. **Gynæcium** : carpels 2, united ; ovary superior, situated on a nectariferous disc, 4-lobed, 4-locular owing to each carpel dividing early into 2 loculi ; style gynobasic ; stigma 2-lobed ; placentation axile ; ovule erect, anatropous. **Fruit** : a group of 4 achenes or nutlets, each containing a seed ; sometimes a drupe. **Seed** : albumen scanty or absent.

**Pollination** : Insect-pollinated. Honey is secreted by a disc at the base of the pistil and protected by hairs and by a constriction of the corolla—tube. The flowers are often protandrous but, in some, cross-pollination is due to the peculiar structure of the flower.

**Distribution** : Mostly natives of temperate climates but the more fragrant kinds occur most abundantly in the warm temperate and drier regions.

**Affinities** : This Order is related to the *Boraginaceae* in the structure of the ovary. It also bears affinity to the *Verbenaceae* but is distinguished by the greater degree of union of the carpels and the terminal style.

**Properties & Uses** : The most striking qualities of this Order depend upon the presence of aromatic or fragrant essential oils which render some of them as valuable stimulants and antispasmodics ; others flavour herbs and ingredients in perfumes etc. : Some are regarded as tonics. Fleshy rhizome and tuber of some are eaten.

## Inter. Questions on "Labiatae" from 1909-22.

1. Define the Order—*Solanaceae* and *Labiatae* (C. U. 1910).

2. Refer the following plant to its Natural Order and give reasons for your answer—*Tulsi* plant (c. u. 1912).

**Ans:** State the *important characteristics* of Tulsi plant which belongs to the *Labiatae.*

3. Compare the essential structures which determine a plant as belonging to the *Labiatae* and those which determine a plant as Leguminosae (c. u. 1914)

**Ans:** State the important characteristics of the *Labiatae.*

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## SOLANACEAE *(Dicot.) Fig. 268, 269. (C. U. 1910, 1911; 1921).

**Examples:** আলু (Alu, Potato, *Solanum tuberosum*); বেগুন (Begun, Brinjal, *Solanum Melongena*); কণ্টিকারি (Kantikari, *Solnum Xanthocarpum*); লঙ্কা (Lanka, *Capsicum-frutescens*); টাঁপারী (Tanpari, *Physalis peruxviana*); ধুতুরা (Datura, *Datura Stramonium*): তামাক (Tamak, Tobacco, (*Nicotiana Tabacum*); বিলাতিবেগুন (Bilatibegun, Tomato, *Lycopersicum esculentum.*

**Floral Formula:** K (5) C (5) A 5 G (2)

### Description.

**Habit**: herbs, shrubs or rarely small trees. **Leaves**: alternate, often in unequal pairs. **Inflorescence**: cymose. **Flowers**: hermaphrodite, sometimes zygomorphic. **Calyx**: sepals 5 united, usually persistent. **Corolla**: petals 5 united, of various forms, rarely 2-lipped, often folded and convolute. **Androecium**: Stamens 5, epipetalous, alternating with petals, or fewer in zygomorphic

flowers. **Gynaecium** : carpels 2, united ; ovary situated on a hypogynous 2-disc, 2-locular or imperfectly 1-locular or sometimes many locular owing to secondary divisions ; ovules 1-many in each locular, anatropous ; placentation axile ; style terminal. **Fruit** : capsule or berry. **Seed** : albuminous.

**Distribution** : Most abundant in the tropics

**Affinity** : Closely related to the *Scrophulariaceae.*

**Properties & Uses** : Generally characterised by narcotic poisonous properties ; some have an acrid quality, some have diuretic action and others are used as tonics. Certain kinds furnish wholesome and some important articles of food.

### Inter. Questions on "Solanaceae" from 1909-22.

1. Define the Orders – *Solanaceae* and Labiatae (c.u. 1910).
2. How do you distinguish between Malvaceae, *Solanaceae* and Commelynaceae ? Give sketches (c u.1911).
   Ans : State *important characters.*
3. Describe the Natural *Order, Solanaceae* in detail with sketches (c.u. 1921).

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## SCROPHULARIACEAE (Dicot.) Figs. 270,271.

**Floral Formula** : K $\overset{(5)}{\underset{}{}}$ $\overset{\frown}{C}$ $\overset{(5)}{\underset{}{}}$ A 4 or 2 G $\underline{(2)}$

### Description.

**Habit** : herbs or shrubs, rarely trees, often semi-parasitic, rarely quite parasitic on roots. **Leaves** : all, or the lower only, opposite, rarely all alternate or whorled. **Inflores-**

**cence** : racemose (spike or raceme) or cymose (usually dichasia, often united into complex corymbs ; bracts and bracteoles present. **Flowers** : hermaphrodite, zygomorphic, sometimes nearly regular. **Calyx** : sepals 5 united, 5-lobed, rarely 4, usually persistent. **Corolla** : petals, 5 united, more or less 2-lipped, sometimes personate, 4-5 lobed. **Androecium** : stamens 4, didynamous, epipetalous, sometimes 2 or 4 perfect and 1 staminode. **Gynæcium** : carpels 2 united in a 2-locular superior ovary situated on a honey-secreting *disc* ; ovules usually many, anatropous ; placentation axile. **Fruit** : usually a capsule, rarely a berry. **Seed** : usually albuminous.

**Pollination** : generally insect-pollinated ; in default of insect-visits, self-pollinated.

**Distribution** : universally diffused.

**Affinities** : This Order is nearly related to the *Orobanchaceæ* in the general structure of the flower but differs from it in having axile placentation instead of parietal placentation of *Orobanchaceæ*. A general resemblance exists between this Order and the other didynamous gamopetalous Orders, but *Gesneraceae*, *Pedaliaceae* and *Crescentiaceae* have parietal placentas, *Bignoniaceae* and *Acanthaceæ* have exalbuminous seeds and *Lentibulaceae* has a free central placentation.

**Properties & Uses** : More or less acrid or bitter ; mostly unwholesome ; sometimes deadly poisons.

## BIGNONIACEAE (Dicot.)

**Example :** আটকপালি (Atcapali, *Stereospermum chelonoides.*)

**Floral Formula :** $K_{(5)}\ \widehat{C_{(5)}\ A_{4}}\ G_{(2)}$

### Description.

**Habit :** trees and shrubs, most commonly lianes, very rarely herbs. **Leaves :** usually opposite, compound. **Inflorescence:** usually dichasial cyme, sometimes raceme or panicle ; bracts and bracteoles present. **Flowers :** hermaphrodite, zygomorphic. **Calyx :** sepals 5 united, 2-5 lobed. **Corolla :** petals 5 united, usually 2-lipped. **Androecium ;** stamens 4, didynamous, epipetalous ; often a rudimentary and rarely a fifth perfect stamen present ; anther-lobes usually situated one above the other. **Gynaecium :** carpels 2 united into a 2-locular superior ovary which is situated on a hypogynous *disc* ; ovules usually many ; placentation axile. **Fruit :** a capsule. **Seed :** exalbuminous, flattened and winged.

**Distribution :** Mostly tropical.

**Affinities :** This Order is closely related to the *Scrophulariaceae*, *Acanthaceae* and *Gesneraceae*. There is also some distant relation with the *Pedaliaceae* and *Crescentiaceae*. **Properties & Uses :** Many of the plants of this Order are used in Brazil for various purposes, such as dyes, medicines of various action, timber etc. but none are of very great importance.

## ACANTHACEAE* (Dicot.) C. U. 1918.

**Examples :** কালমেঘ (Kalmegh, *Andrographis paniculata*); বাকস (Bakash, *Adhatoda Vasica)* ; কুলেখারা (Kulakhara, *Hygrophila spinosa*).

**Floral Formula :** $K_{(4-5)}\ \overset{\frown}{C_{(4-5)}\ A_{4}}\ G_{(\underline{2})}$

### Description.

**Habit** : herbs or shrubs, rarely trees. **Leaves** : opposite, usually entire. **Inflorescence** : cyme, raceme or spike ; bracts and bracteoles usually present, often coloured ; the latter frequently large, more or less enclosing the flowers. **Flowers** : hermaphrodite, zygomorphic. **Calyx** : sepals 5 or 4, free or united below. **Corolla** : petals 5, rarely 4, united in a 2-lipped, less often 5-lobed corolla. **Androecium** : stamens usually 4 or 2, rarely 5, epipetalous ; anthers 2- or 1-called. **Gynæcium** : carpels 2 united in a superior, 2-locular ovary which is usually situated on a nectariferous *disc* ; ovules 1 or more in each loculus, anatropous. **Fruit** : usually a bi-locular capsule. **Seed** : usually exalbuminous.

**Distribution** : Chiefly tropical.

**Affinities** : This Order is closely related to the *Scrophulariaceae* and *Bignoniaceae*, differing from the former in the exalbuminous seeds, from the latter chiefly in the structure of the placenta and in the seeds not being winged.

**Properties & Uses** : Mostly without active properties.

### Inter. Questions on "Acanthaceae" from 1909-22.

Describe as fully as you can any of the following families—Compositæ, *Acanthaceae*, Gramineae (C. U. 1918).

*Cohort* : **Rubiales.**

Leaves usually opposite ; flowers, typically 5-4—merous regular, irregular or zygomorphic ; ovary multi-locular or one-locular with 1-many anatropous ovules in each loculus :

Natural Order : **Rubiaceæ.**

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## RUBIACEAE* (Dicot.) Fig. 272 (C. U. 1911, 1915).

**Examples** : কদম (Kadam, *Anthocephalus Cadamba*) ; ক্ষেৎপাপ্‌রা (Khetpapra, *Oldenlandia corymbosa*) ; রঙ্গন (Rangan *Ixora coccinea*) ; জুই (Jui, *Pavetta tomentosa*) ; গন্ধরাজ (Gandha, raj, *Gardenia florida*).

**Floral Formula** : K $\overset{4\text{-}5}{}$ C $\overset{(4\text{-}5)}{}$ A $\overset{4\text{-}5}{}$ G $\overline{(2)}$

### Description.

**Habit** : Trees, shrubs or herbs. **Leaves** : opposite decussate, usually entire, stipulate ; stipules interpetiolar or intrapetiolar or united with one another and to the petioles to form as heath round the stem or sometimes as large as ordinary leaves. **Inflorescence** . commonly a much branched cymose panicle, less frequently dichasia. **Flowers**: usually hermaphrodite, regular. **Calyx** : sepals usually 4-5, united in a tube attached to the ovary. **Corolla** : petals usually 4-5, united, valvate, convolute or imbricate. **Androecium** : stamens 4-5, epipetalous, alternating with petals. **Gynaecium** : carpels usually 2, rarely 1-to many, united in an inferior, 2- locular ovary ; ovules 1 or more in

each loculus. **Fruit** : a capsule, berry or schizocarp. **Seed** : albuminous.

**Distribution** : Mostly tropical ; a few occur in the cool parts of the Northern hemisphere and the mountains of the Southern.

**Affinities** : This Order is nearly related to the *Caprifoliaceae* and *Loganiaceae*. It is also distantly related to the *Umbelliferae* and *Compositae*.

**Properties & Uses** : Some are emetic and purgative ; others febrifuge and tonic ; others stimulant and restorative ; some are astringent ; a few have edible fruits ; some yield valuable dye-stuffs.

### Inter. Questions on "ubiaeae "from 1909-22.

1. How do you distinguish between *Rubiaceae* and Compositae ; give sketches ? (C. U. 1911).

**Ans**. State the *important characteristics* of Rubiaceae.

2. Write a short essay on *Rubiaeeae* (C. U. 1915).

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*Cohort* : **Companulatae.**

Flowers typically 5-merous ; anthers close together and often more or less united ; ovary multi-locular with 1 to many ovules, or 1- locular with 1 ovule.

Natural Orders . **Cucurbitaceae, Campanulaceae, Compositae.**

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## CUCURBITACEAE *( Dicot. ). Fig. 273

## ( C. U. 1912, 1920 ).

**Examples :** পটল (Patal, *Trichosanthes dioica*) ; মাকাল (Makal, *Trichosanthes palmata*) ; লাউ (Low, *Lagenaria vulgaris*) ; ধুঁদুল (Dhundul, *Luffa aegyptiaca*) ; ঝিঙ্গে (Jhinga, *Luffa acutangula*) ; চালকুমড়া (Chalkumra, *Benincasa cerifera*) ; করলা (Karala, *Momordica Charantia*) ; খরবুজ (Kharbuz, *Cucumis Melo*) ; শশা (Sasa, *Cucumis sativus*) ; তরবুজ (Tarbuz, *Citrullus vulgaris*) ; তেলাকুচো (Telakucha, *Cephalandra indica*) ; মিঠাকুমড়া (Mithakumra, Gourd, *Cucurbita maxima*).

**Floral Formula :** K (5) C (5) A 5 G (3)

### Description.

**Habit :** chiefly annual herbs climbing by tendrils, a few are shrubs. **Leaves**: alternate. **Inflorescence :** usually a panicle, rarely sub-umbellate. **Flowers :** monoecious or dioecious. **Calyx :** usually 5-toothed by the union of 5 sepals. **Corolla :** petals 5, more or less united, inserted on the calyx-limb. **Androœcium :** stamens 5, springing from the corolla and alternating with its segments, more frequently triadelphous with 2 pairs and 1 odd one, sometimes free or monadelphous, very rarely 3 or 2 ; anthers 2 locular, usually long and sinuous. **Gynæcium :** carpels usually 3, united in an inferior, usually 3-locular, sometimes 1 or more locular ovary ; ovules 1-many in each loculus ; usually 3 placentas placed parietally but on the involute margins of the carpels so as to meet in the centre. **Fruit :** a berry-like fruit, sometimes called a pepo. **Seed :** mostly flattened, exalbuminous.

**Distribution:** Chiefly natives of hot climates.

**Affinities :** This Order is closely related to the *Begoniaceae* and *Loasaceae*. There is also a certain approach to the polypetalous *Onagraceae* and gamopetalous *Campanulaceae*.

**Properties & Uses :** The majority of the plants of this Order possess a purgative property. Some kinds may be reckoned as poisons, while others, especially when cultivated, become innocuous. The milder species furnish esculent fruits and vegetables.

### Inter. Questions on "Cucurbitaceæ" from 1909-22.

1. Refer the following plant to its Natural Order and give reasons for your answer—the Melon (C. U. 1912).

2. Describe, in detail, the characteristics of the Natural Order, *Cucurbitaceae* (C. U. 1920).

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## CAMPANULACEAE (Dicot.)

(Words in italics denote *distinguishing characters*).

**Floral Formula :** K 5 C (5) A 5 G (3)

### Description.

**Habit :** mostly perennial herbs with usually *milky juce*, a few shrubs and trees. **Leaves :** usually alternate. **Inflorescence:** generally racemose. **Flowers :** usually hermaphrodite, regular or zygomorphic. **Calyx :** sepals 5 *free*, narrow, so that the aestivation is open. **Corolla :** petals 5 united in a regular or irregular corolla. **Andrœcium :** stamens 5, *free* ; anthers introrse, sometimes united. **Gynæcium :** carpels usually 3, sometimes 2 or 5, united in an inferior 2-5-locular ovary ; ovules usually many, anatropous ; placentation axile. **Fruit :** a *capsule* or berry. **Seed :** albuminous.

**Pollination :** Honey is secreted on the upper surface of the ovary and protected by the broad bases of the stamens. The latter ripen very early and shed their pollen on to the

hairy style. The stigmas ripen much later, and in many cases, if not already cross-pollinated, will curve right back and pick up the pollen from their own style.

**Distribution** : The plants belong mostly to the temperate parts of the Northern hemisphere.

**Affinities** : Nearly related to the *Compositae* and *Vacciniaceae.*

**Properties & Uses** : The young roots aud shoots of many, especially when cultivated, are often edible. Some yield a violent poison which is emetic or purgative and which causes great depression of the pulse, perspiration and in large doses, death.

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## COMPOSITAE (Dicot.) Figs. 274, 275 (C. U. 1909 1911, 1916, 1918, 1921).

(Words in italics denote *distinguishing characters*).

**Examples** : গেঁদা (Genda, *Tagetes patula*) ; সূর্য্যমুখী (Surjja-mukhi, Sunflower, *Helianthus annuus*) ; হিংচেশাক (Hingcha-shak, *Enhydra fluctuans*) ; কুসুম (Kusum, Safflower, *Carthamus tinctorius*).

**Floral Formula** : K C A G
pappus (5) 5 (2)

### Description.

**Habit** : herbs or shrubs, rarely trees. **Leaves** : simple, alternate or opposite. **Inflorescence** : usually *capitulum*, rarely spike ; in many cases, the capitula are arranged in raceme, corymb etc. or even into compound capitula ; the capitulum is surrounded by an *involucre* of bracts and consists of perfect and imperfect florets closely packed, all similar, or of two kinds, those of the centre or *disc* and those of the circumference or *ray* ; florets often accompanied by membraneous scale-like bracts called *paleae.* **Flowers** : hermaphrodite or unisexual, zygomorphic or actinomorphic. **Calyx** : obsolete, entire, or replaced by a circle of scales, bristles, or feathered or simple hairs (*pappus*) which is often persistent. **Corolla** : petals 5 united into ligulate or tubular

corolla **Androecium** : stamens 5 epipetalous ; anthers *syngenesious*, introrse. **Gynæcium** : carpels 2 united into 1-locular, *inferior* ovary ; ovule 1 erect ; style bifid at the apex with a distinct stigmatic surface on each branch. **Fruit** : a *cypsela*, often crowned by pappus. **Seed** : exalbuminous.

This Order is divided into *two suborders*—(1) **Tubuliflorae** : flowers of disc not ligulate, latex absent ; (2) **Liguliflorae** : all flowers ligulate, latex present.

**Pollination** : The flowers are protandrous. In some flowers, self-pollination is brought about by the stigmas curling back to touch the pollen-grains which are caught by the hairs on their own styles.

**Distrbution** : Universally distributed.

**Affinities** : This Order is nearly related to the *Dipsaceae* and *Calyceraceae* but is distinguished by the condition of anthers and ovule. The syngenesious condition, and, in some measure, the general structure of the florets, ligulate and tubular, indicate a near relation also to the *Campanulaceae*, wherein, however, the flowers are not only large and scattered but the ovaries have more than one loculus with many seeds in each.

**Properties & Uses** : The plants of this Order are not generally characterised by any powerful properties ; bitterness is the prevailing quality, accompanied by aromatic secretions and by a special lactescent juice which often contains a more or less active narcotic principle.

## Inter. Questions on "Compositae" from 1909-22.

1. Describe a member of the *Compositae*. Name the plant that you are describing and underline in your description those features which are characteristic of this Order (C. U. 1909).

2. How do you distinguish between Rubiaceae and *Compositae* ? Give sketches. (C. U. 1911.)

3. Write a short essay on the *Compositae*. (C. U. 1916).

4. Describe, as fully as you can, any of the following families—*Compositae*, Acanthaceae and Gramineae (C. U. 1918).

5. Describe the Natural Order, *Compositae*, with sketches (C. U. 1921).

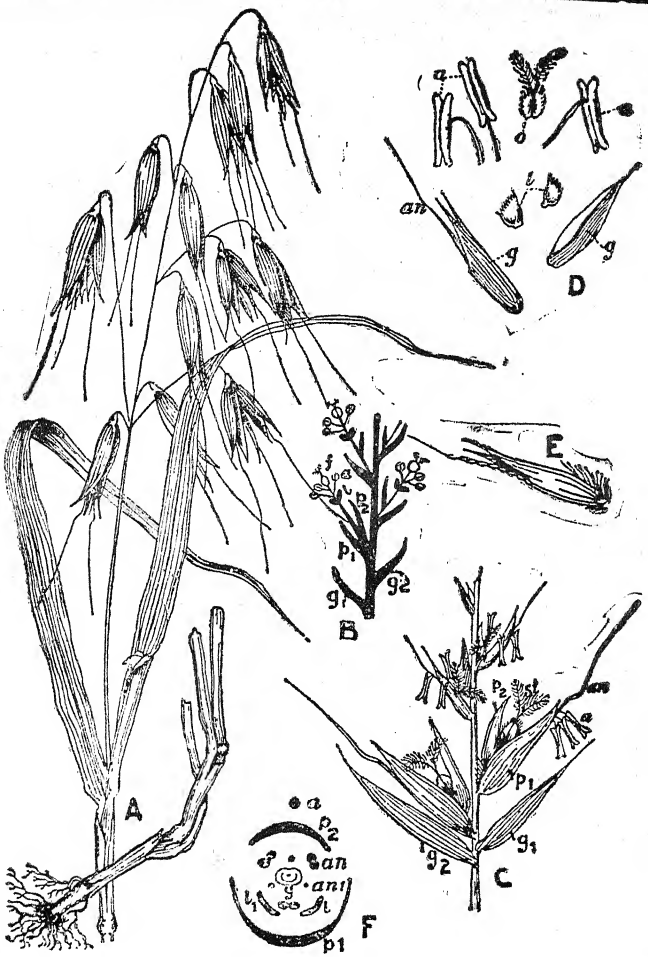



Fig. 223. Gramineae (জব, Oat, ***Avena sativa***).

A—Complete plant. B—Single *spikelet* (diagrammatic, as the axis on which the flowers are arranged has been elongated) showing *glumes* ($g_1$, $g_2$), *palea* ($p_1$, $p_2$), *lodicules* (l), stamens (a) and *pistil* (f). C—*Spikelet* showing *glumes* ($g_1$, $g_2$), *palea* ($p_1$, $p_2$), *stamens* (a), *awn* *awn* (an) *lodicules* (l), *stamens* (a) and *ovary* (o). E—*Fruit* enclosed in its *palea*.

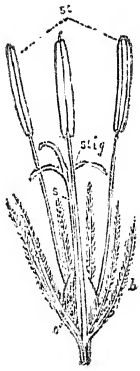



Fig. 224. Cyperaceae.

(মুথোঘাস, ***Cyperus rotundus***).

*Bristles* (b) forming a kind of perianth, *stamens* (st), *ovary* (o), *style* (s), *stigma* (stig).

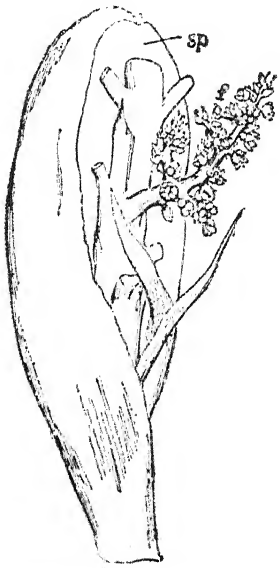



Fig. 225. Palmaceae.

(নারিকেল, Cocoanut, ***Cocos nucifera***).

*Spathe* (sp), *flowers* (f).

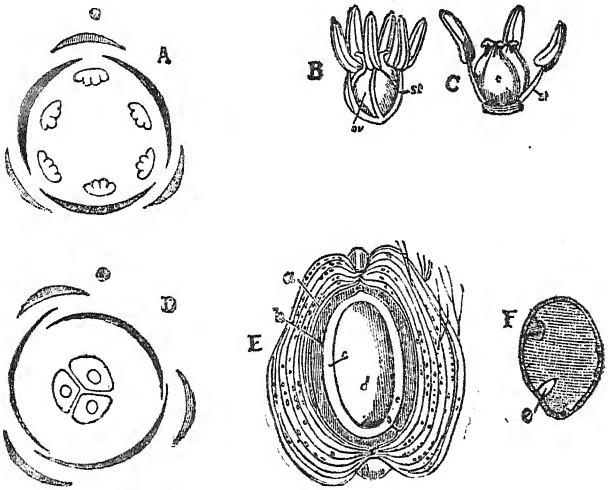



Fig. 226. Palmaceae (Cocoanut).

A—Floral diagram of a *male flower* containing 6 *perianth* leaves and 6 *stamens*. B—*Hermaphrodite* flower of a kind of Palm with the *perianth* removed, showing *stamens* (st) and *ovary* (ov). C—Same hermaphrodite flower with perianth and 3 stamens removed showing 3 carpels (c) composing the pistil. D—Floral diagram of a *female flower* containing 6 perianth leaves and 3-celled ovary. E—Section of fruit of cocoanut showing the two outer layers (a) of *pericarp*, *endocarp* (b), *endosperm* (c) and cavity (d) of the endosperm. F—Vertical section of seed showing *embryos* (e).

Fig. **227. Palmaceae** (Cocoanut Plant).

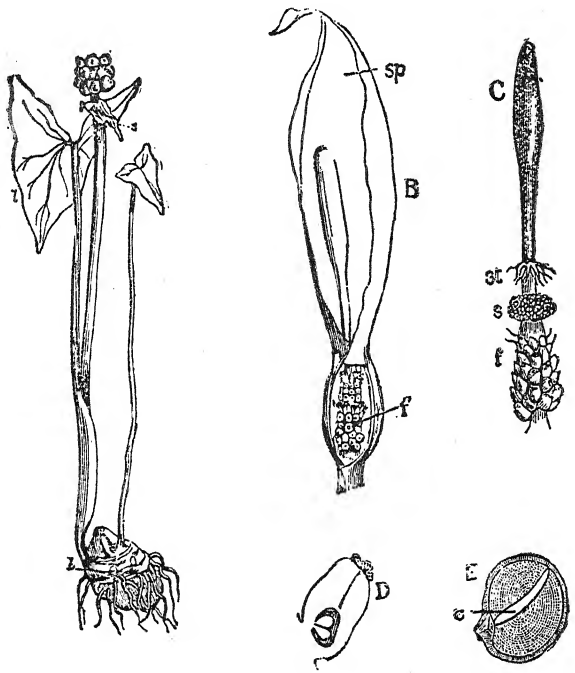



Fig. 228. Araceae (কচু, Kachu).

A—Plant in fruit showing *corm* (b), *leaf* (l), remains of *spathe* (s) and collection of fruits at the top. B—*Inflorescence* (spadix) with *spathe* (sp) and *flowers* (f). C—*Inflorescence* with the spathe removed, showing the *female flowers* (f), *male flowers* (s) and some *staminodes* (st). D—Vertical section of the *ovary*. E—Vertical section of seed.

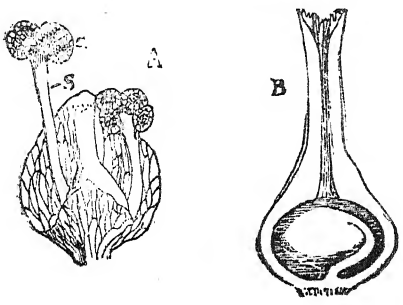



Fig. 229. Lemnaceae.

A—*Male flower* with 4-locular anther (a) and filament (s). B—*Female flower.*

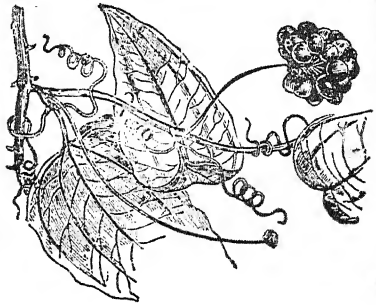


Fig. 230. Liliaceae.

(কুমারিকা, ***Smilax macrophylla***)

Portion of a branch bearing *leaves*, *fruits* and *stipules* modified into *tendrils.*

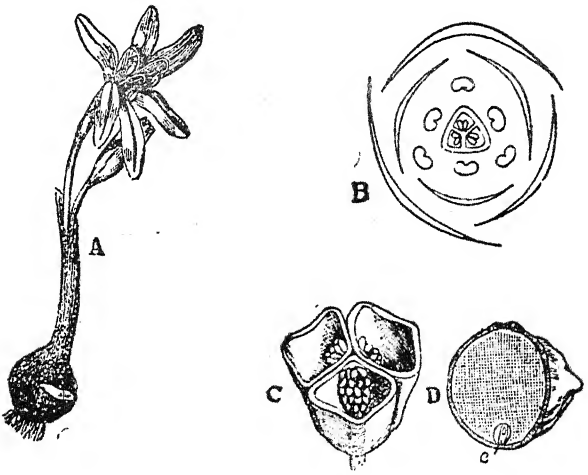



Fig. 231. Liliaceae.

A—Flowering plant of *Colchicum* (Liliaceae). B—Floral diagram of *Colchicum*. C—Transverse section of the fruit of *Colchicum*. D—Vertical section of the seed showing *embryo* (e).

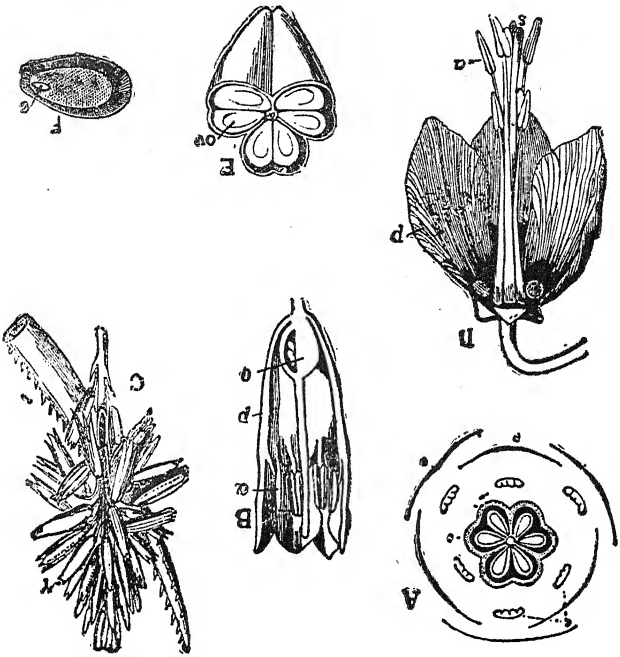



Fig. 232. Liliaceae.

A—Floral diagram of a Lily. B—Vertical section of a flower of Liliaceae showing *ovary* (o), *perianth* (p) and *anther* (a). C—Portion of a succulent *leaf* (l) of *Aloe* (Liliaceae) bearing *flowers* (f). D—Section of a flower of Liliaceae showing *perianth* (p), *stamens* (a) and *stigma* (s). E—Transverse section of the *ovary* (ov) of a Lily. F—Vertical section of the seed of Lily showing *embryo* (e).

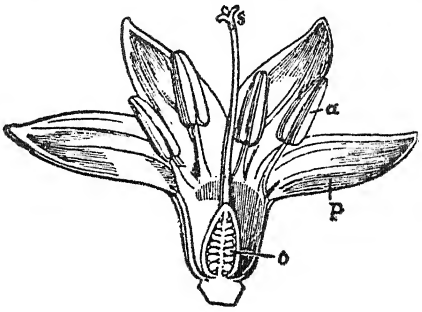



Fig. 233. Flower of Dracaena (Liliaceae).

Flower of *Dracaena* showing *perianth* (p), *stamens* (a), *stigma* (s) and *ovary* (o).

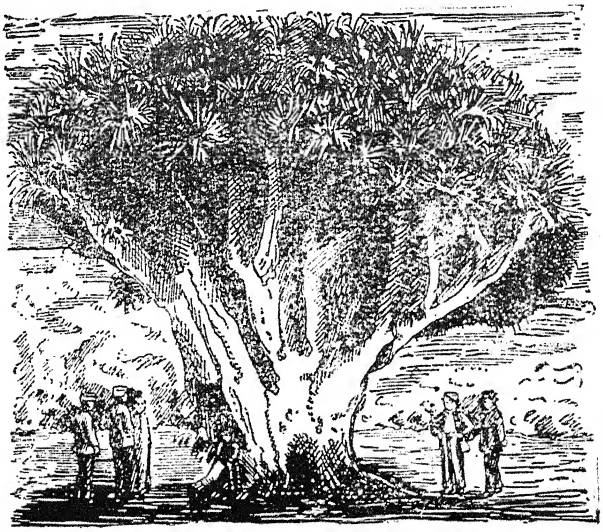


Fig. 234. Dracaena (*Liliaceae*).

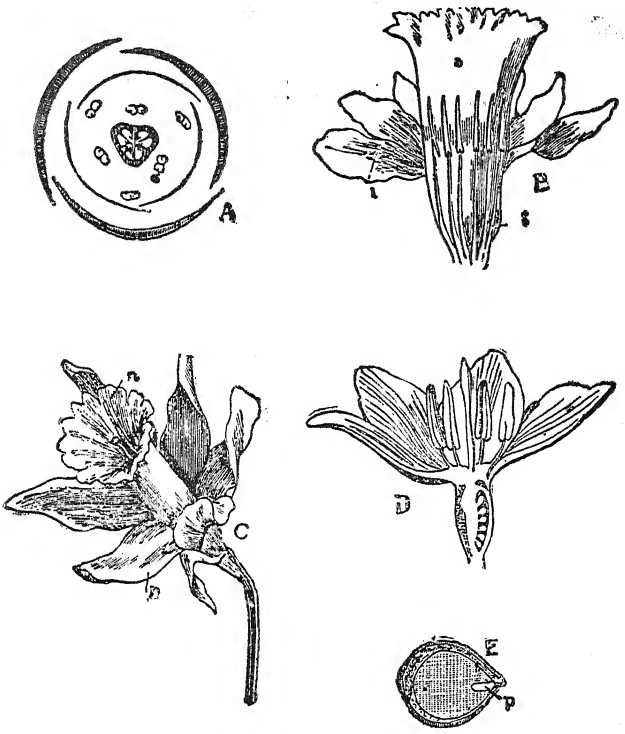



Fig. 235. **Amaryllidaceae.**

A—Floral diagram of a flower belonging to *Amaryllidaceae*, showing 6 perianth leaves, 6 stamens and 3-celled ovary. B—*Corolla-tube* (t) to which 6 stamens are attached, *perianth* (l) and *corona* (n). C—6 *perianth* leaves (p) and *corona* (n) in the centre. D—Vertical section of a flower. E—Vertical section of a seed with *embryo* (p).

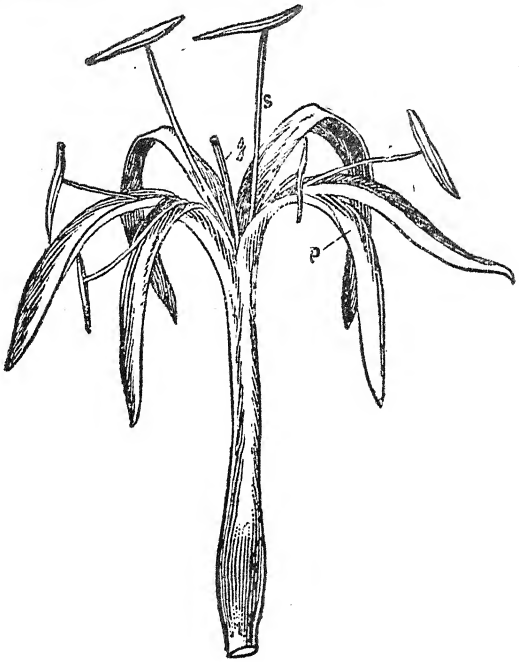



Fig. 236. Amaryllidaceae
*Perianth* (p), *stamens* (s) and *pistil* (j).

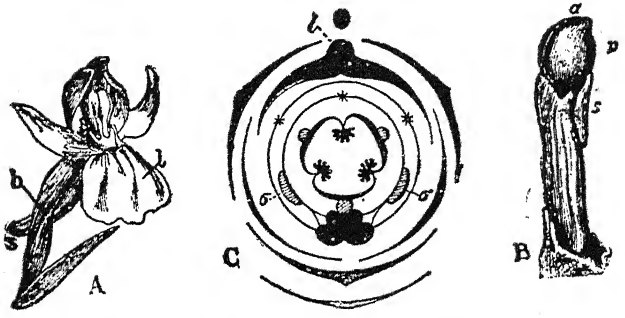



Fig. 237. Orchidaceae (রাস্না, Rasna).
A—Flower of an *Orchid* showing *twisted ovary* (b), *sepal* (s) and *labellum* (l). B—Stylar column of an *Orchid* showing *anther* (a) and stigma (s). C—Floral diagram of an Orchid with *labellum* (l).

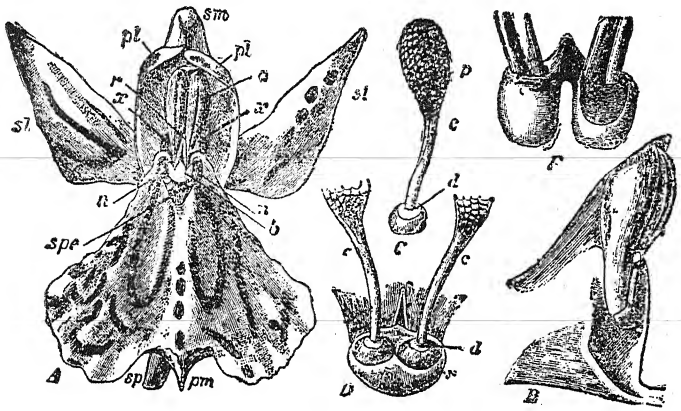



Fig. 238. Orchidaceae (রাস্না, Rasna).

A—Front view of the flower of an Orchid showing *stamen* (a), *cup* (b), *stigma* (n), *staminode* (x), *spur* (sp), entrance to the spur (spe), 3 exterior *perianth leaves* (sm, sl), *labellum* (pm), 2 interior *perianth leaves* (pl). B—Side view of the stylar column. C—A *pollinium* with *massulae* (p), *caudicle* (c) and adhesive *disc* (d). D—Two *caudicles* (c) with the *disc* (d) embedded in the *cup* (r). F—*Rostellum* and the base of the anther-loculus.

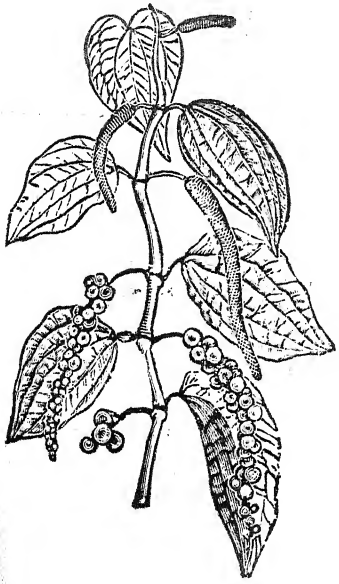


Fig. 239. Piperaceae.

(গোলমরিচ, ***Piper nigrum***).

A portion of a branch possessing *leaves*, *inflorescence* at the top and a collection of *fruits* at the bottom.

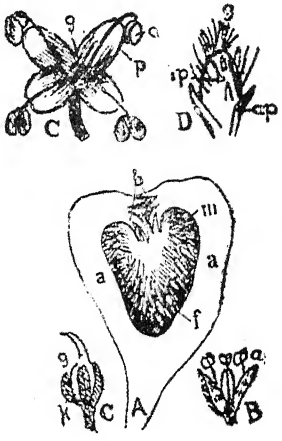



Fig. 240. Urticaceae.

**A**—Section of *inflorescence* of Dumar showing fleshy axis (a), *female flowers* (f), *male flowers* (m) and *bracts* (b). **B**—a *male flower* with stamens (a). **C** (lower)—a *female flower* with *calyx* (k) and *pistil* (g). **C** (upper)—*male flower* of stinging Nettle (Urticaceae) showing *perianth* (p), *stamens* (a) and *rudimentary ovary* (g). **D**—*female flower* of Stinging Nettle showing *outer perianth* (ap), inner perianth (ip) upon the *pistil* (g).

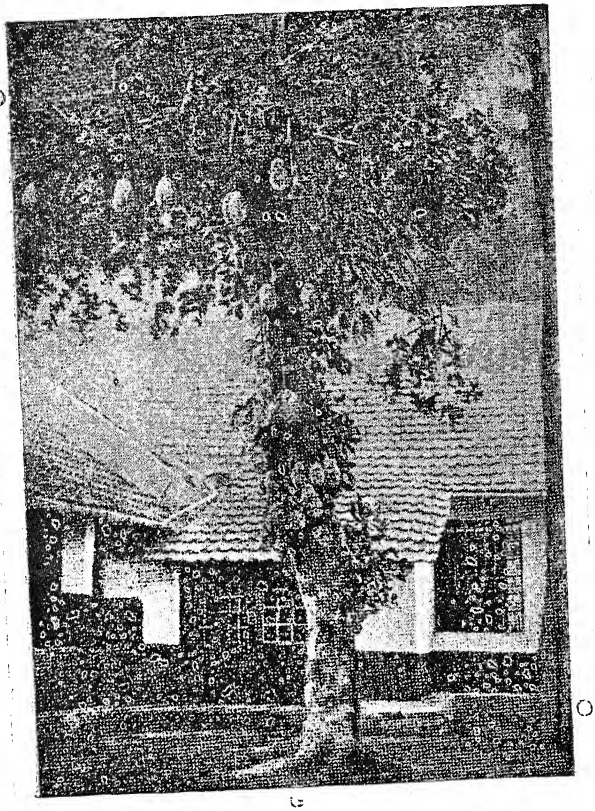


Fig. 241. **Urticaceae** (কাঁঠাল, Jack-fruit).

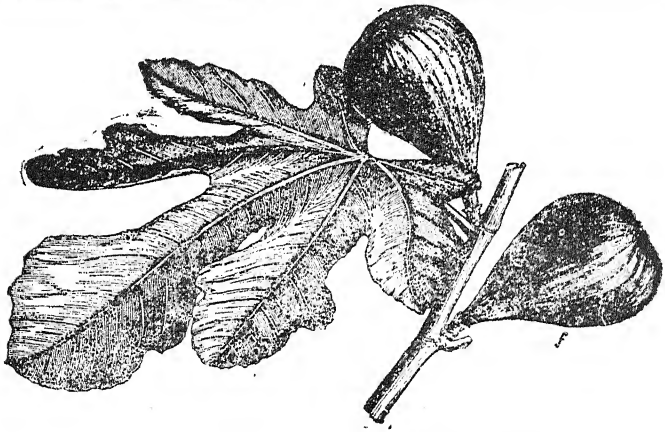



Fig. 242. Urticaceae (ডুমুর, ***Ficus Cunia***).
2 Fruits (f) and 1 *leaf*.

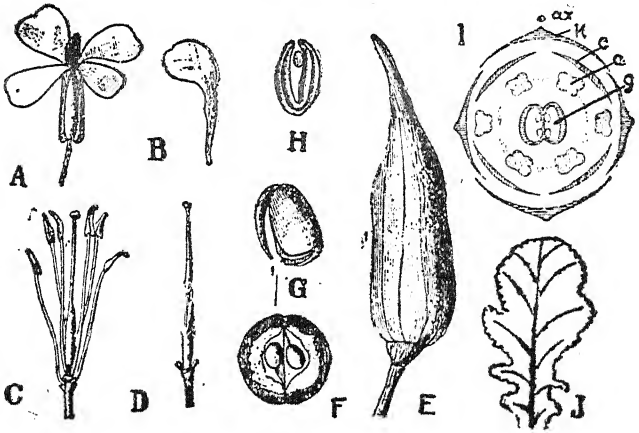



Fig. 243. Cruciferae (মূলা, Radish).
A—*Cruciform* flower. B—A *petal* with the upper *limb* and lower *claw*. C—*Tetradynamous stamens* and *pistil*. D—*Pistil*. E—*Fruit*. F—Transverse section of fruit. G & H—Seed and its section. I—Floral diagram showing mother-axis (ax), *calyx* (k), *corolla* (c), *androecium* (a), *pistil* (g). J—A *leaf*.

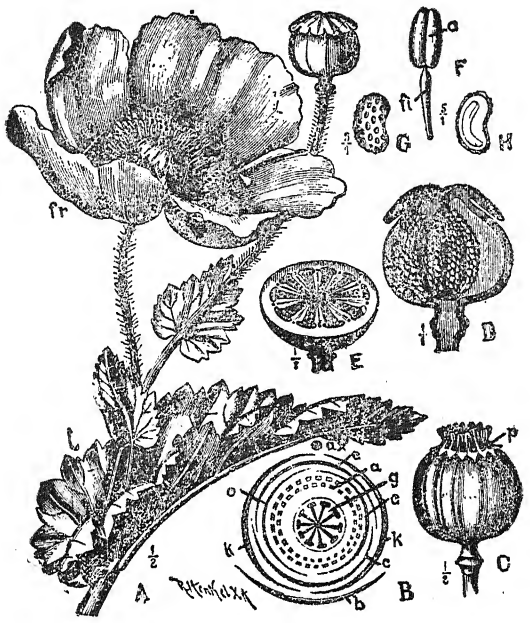



Fig. 244. Papaveraceae (আফিম, ***Opium Poppy***).

A—A portion of a branch bearing *flower* (fr) and *leaf* (l). B—Floral diagram showing *mother-axis* (ax), *bract* (b), *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g). C—*Fruit* with *pores* (p) to liberate the seeds. D & E—Vertical and Transverse section of ovary. F—*Stamen* with *filament* (fl) and *anther* (a). G & H—*Seed* and its section.


Fig. 245. Leguminosae (leaf). (মটরশুঁটি, Pea).

*Leaf* showing *stipules* (st), *leaflet* (l) and *tendril* (t).

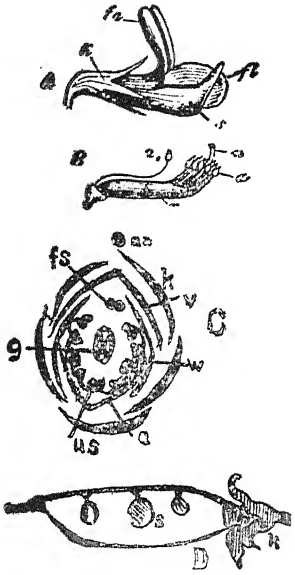



Fig. 246. Leguminosae (flower & fruit) (মটরশুঁটি, Pea).

A—*Papilionaceous flower* with *calyx* (k), *standard* (fa), *wing* (fl), *keel* (s). B—Same flower with calyx and corolla removed showing 9 *united stamens* (a), 1 *free stamen* ($a_1$) and *style* (n). C—Floral diagram of Papilionaceous flower showing *mother-axis* (ax), *calyx* (k), *vexillum* (v), *wings* (w), *keel* (c), 9 *united stamens* (us) and 1 *free stamen* (fs), *pistil* (g). D—A *fruit* with persistent *calyx* (k) and *seeds* (s).

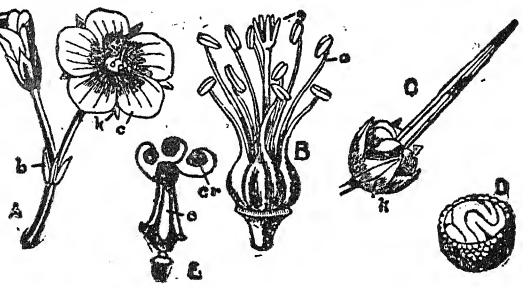



Fig. 247. Geraniaceae.

A—A branch bearing *bracts*, flowers with *calyx* (k) and *corolla* (c). B—*Androecium* (a) and *Gynaecium* (g). C—*Fruit* surrounded by persistent calyx (k). D—Transverse section of *seed*. E—*Fruit* with *carpophore* (o) and *carpels* (cr).

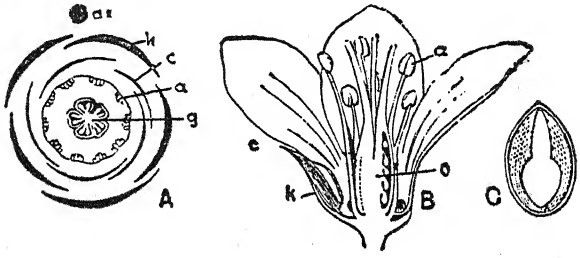



Fig. 248. Oxalidaceae (আমরুল, ***Oxalis corniculata***).

A—Floral diagram showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a), *gynaecium* (g). B—Flower showing *calyx* (k), *corolla* (c), *androecium* (a) and *ovary* (o). C—Section of seed.

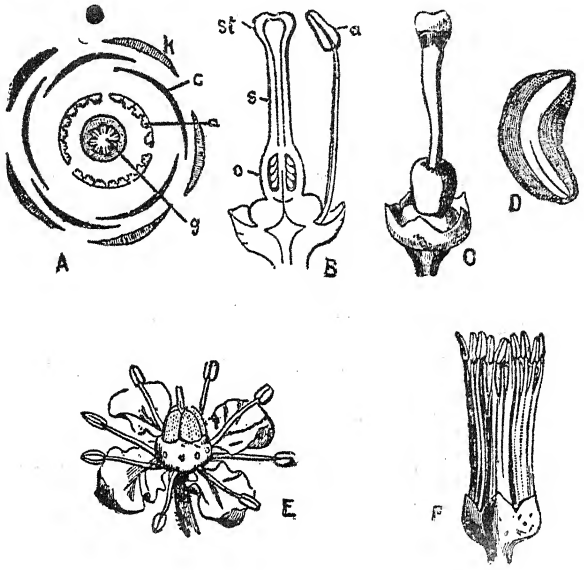



Fig. 249. Rutaceae (পাতিনেবু, ***Citrus acida***).

A—Floral diagram showing *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g). B—A *Flower* with a single *stamen* (a) and pistil composed of *ovary* (o), *style* (s) and *stigma* (st). C—A flower with the *pistil* only. D—Section of the *seed*. E—A flower showing *corolla, androecium, pistil* and a large *disc* beneath the pistil. F—*Androecium* of Orange (Rutaceae) showing polyadelphous stamens.

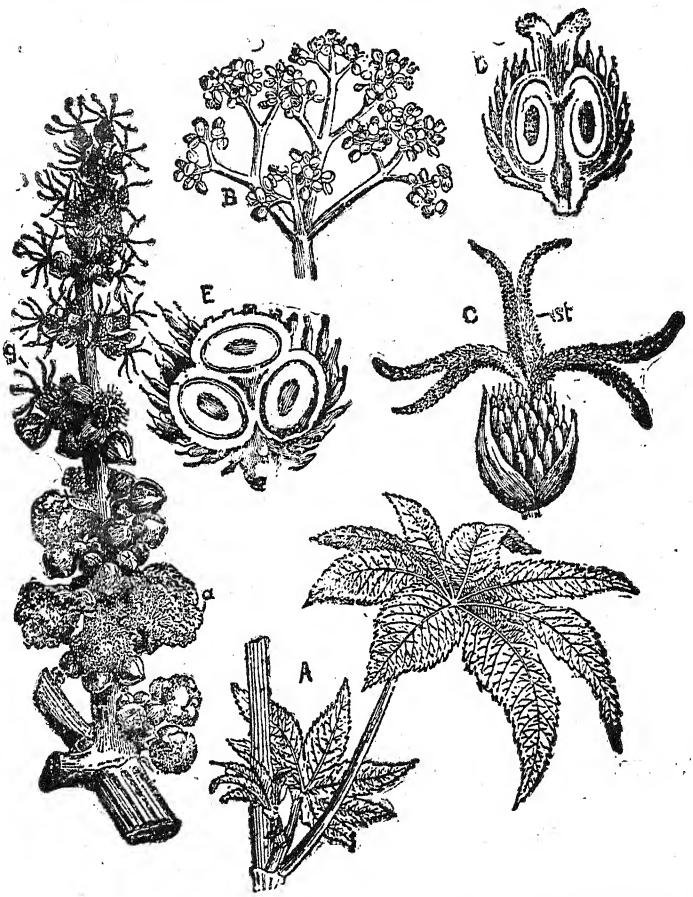



Fig. 250.—Euphorbiaceae (ভেরাণ্ডা, ***Ricinus communis***).

**A**—*Leaves.* **B**—Single *stamen* which is much-branched and looking like a branch of stamens. **C**—A *female flower* with 3 *styles* (st), each style being divided into 2 parts. **D** & **E**—Vertical and Transverse section of *fruit.* **F**—Branch bearing *male* (a) and *female* (g) flowers.

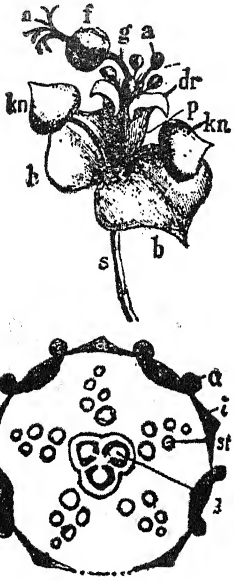



**Fig. 251. Euphorbiaceae.**

Upper figure—Part of inflorescence of *Euphorbia* showing *stalk* (s) *bract* (b), *flower-bud* (kn), *involucre* (p), *gland* (dr), *male-flowers* (a), *female flower* (f) with *stigma* (n).

Lower figure—Diagram of the *Cyathium of Euphorbia* showing *involucre* (i), *gland* (a), *male flower* (st) and *female flower* (g).


**Fig. 252. Anacardiaceae**

(আম, Mango).

*Fruit* (m) and *Leaf* (l).

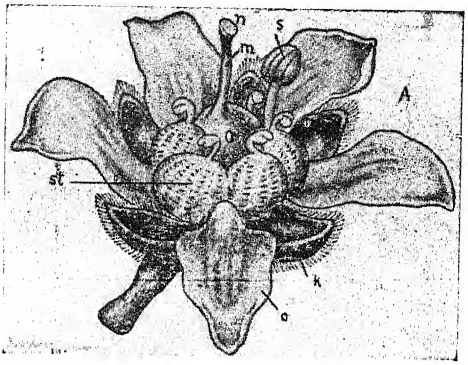



Fig. 253 Anacardiaceae (আম, Mango).

Flower of Mango showing *calyx* (k), *corolla* (c), *stamen* (s), *staminode* (st), *ovary* (o), *style* (m), *stigma* (n).

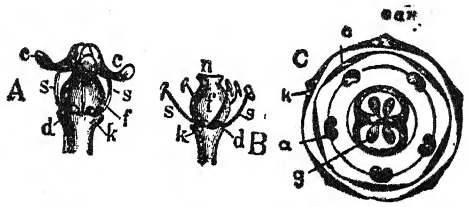



Fig. 254. Vitaceae or Ampelideae (আঙ্গুর, Vine).

**A** & **B**—*Flower* showing *calyx* (k), *corolla* (c), *stamens* (s), *ovary* (f), *stigma* (n), *glands* (d). **C**—Floral diagram showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g).

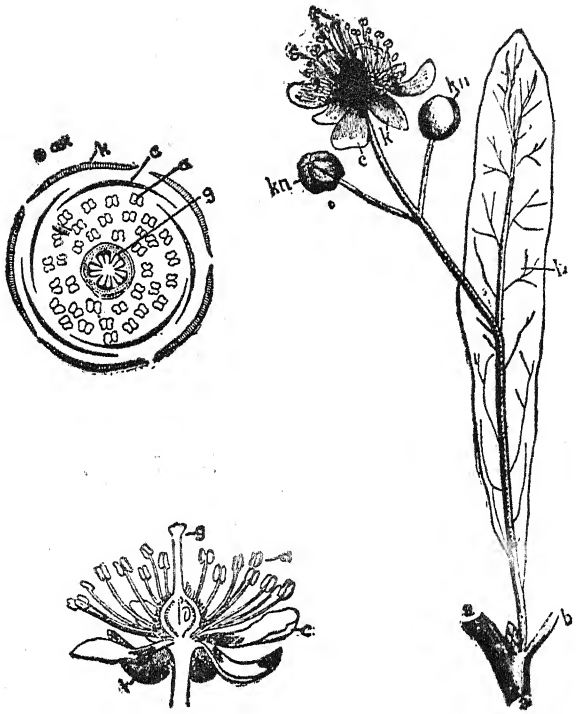



Fig. 255. **Tiliaceae.**

Left upper figure—Floral diagram showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g). Left lower figure—Vertical section of the flower showing *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g). Right figure—*Axis* (a) of the inflorescence; *bracteole* (b) subtending the inflorescence; *flower-bud* (kn), *calyx* (k), *corolla* (c), *stamens* (s) and *pistil* (f).

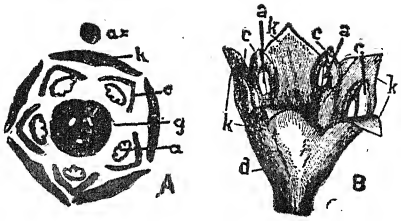



Fig. 256. Rhamnaceae (কুল, ***Zizyphus Jujuba***).

A—Floral diagram showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a), *gynaecium* (g). B—*Flower* consisting of *calyx* (k), *corolla* (c) and *androecium* (a).

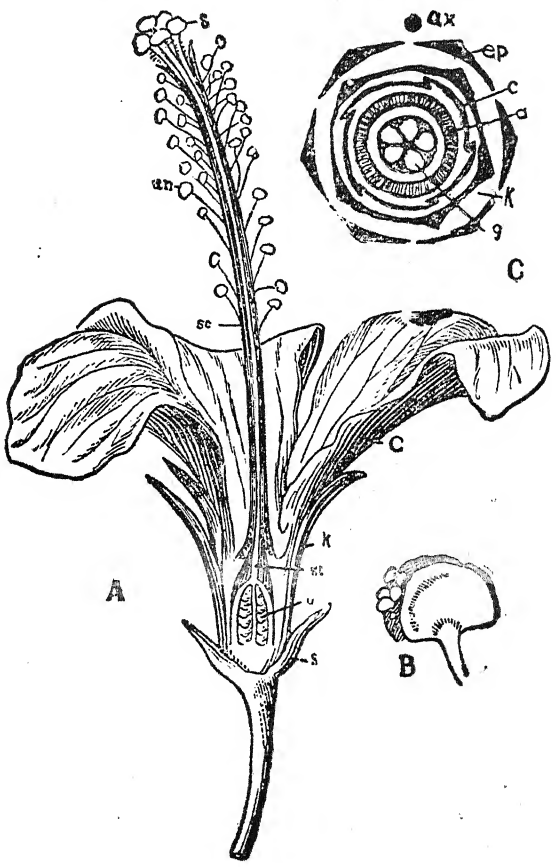



Fig. 257. Malvaceae (জবা, ***Hibiscus Rosa-Sinensis***).

A—Flower showing *epicalyx* (s), *calyx* (k), *corolla* (c), *androecium* consisting of staminal tube (sc) and *half-anthers* (an), *gynaecium* consisting of ovary (o), *style* (st) and *stigma* (S). B—A single *stamen*. C—Floral diagram showing *mother-axis* (ax), *epicalyx* (ep), *calyx* (k), *corolla* (c), *androecium* (a), *gynaecium* (g).

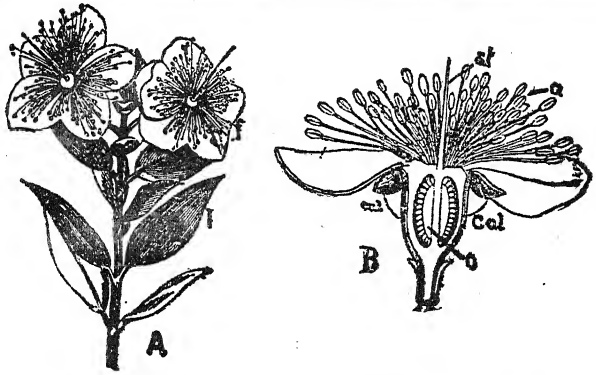



Fig. 258. Myrtaceae (পেয়ারা, ***Psidium Guyava***).

**A**—A branch bearing *leaves* (l) and two *flowers* (f). **B**—Flower consisting of *calyx* (cal), *androecium* (a), *style* (st), *ovary* (o).

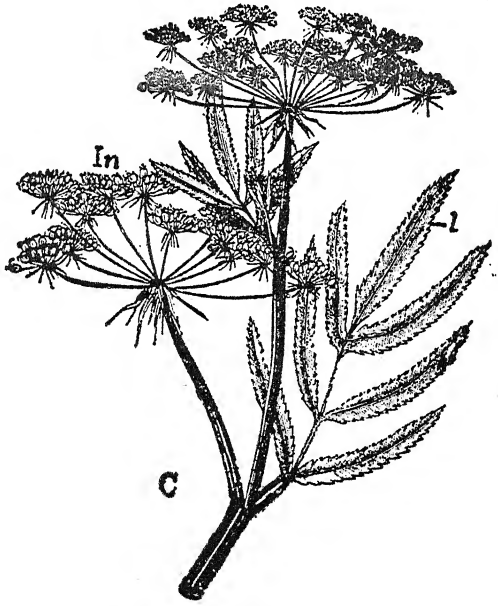



Fig. 259. Umbelliferae.

*Inflorescence* (In), *leaves* (l).


Fig. 260. Umbelliferae.

**A**—Entire *fruit* (f). **B**—Fruit splitting into two *mericarps* (m) which are joined to the *carpophore* (a).

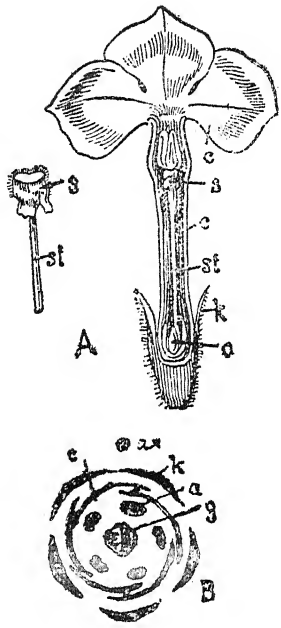



Fig. 261. Apocynaceae (করমচা *Carissa Carandas*).

**A**—Right figure : Flower with *calyx* (k), *corolla* (c), *stigma* (s), *style* (st), *ovary* (o). Left figure : Magnified view of stigma (s), *style* (st). **B**—Floral diagram showing *calyx* (k), *corolla* (c), *androecium* (a), *gynaecium* (g) and *mother-axis* (ax).

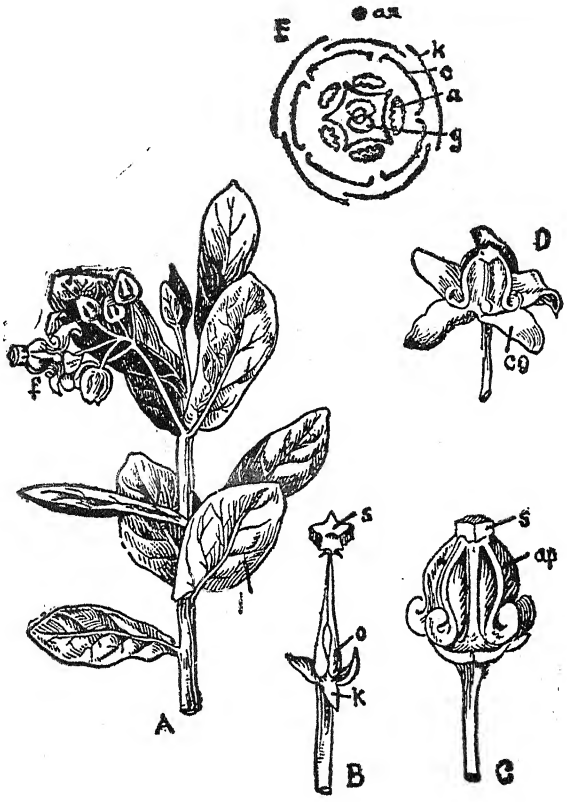



Fig. 262. Asclepiadaceae (আকন্দ Akanda, ***Calotropis gigantea***).

**A**—A portion of branch bearing *leaves* (l) and *flowers* (f). **B**—A flower with the corolla and staminal column removed, showing *calyx* (k), *ovary* (o) and *stigma* (s). **C**—A flower with the calyx and corolla removed, showing the spurred coronal scales (ap) attached to the staminal column ; *stigma* (s). **D**—A flower showing the *corolla* (co), staminal column and spurred coronal scales. **E**—Floral diagram showing the *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g).


Fig. 263. Convolvulaceae.

**A**—A portion of branch bearing two *leaves*, two *flower-buds* and one *flower*. **B**—A flower with a portion of corolla removed, showing *calyx* (k), *corolla* (co), *androecium* (a), *stigma* (st) and *ovary* (o). **C**—A fruit. **D**—A floral diagram showing *mother-axis* (ax), *bract* (br), *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g).


Fig. 264. **Boraginaceae,**

**A**—Shows *inflorescence* (In). **B**—Magnified view of a single *flower with a bract* at the base. **C**—A *fruit* with *mericarps* (m), *torus* (t) and *flower-stalk* (s). **D**—Floral diagram showing the *mother-axis* (ax), calyx (k), *corolla* (c), *androecium* (a) and *gynaecium* (g).

Fig. 265. **Verbenaceae** (ভাঁট, Bhant, ***Clerodendron infortunatum.***

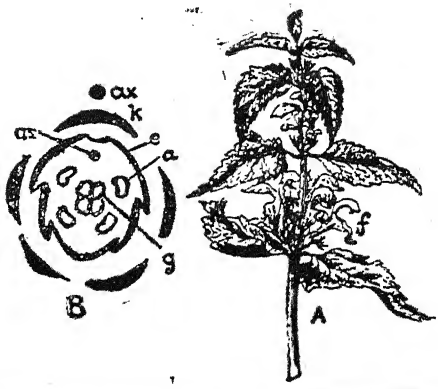
*Calyx* (k), *corolla* (c), *androecium* (a) straight, *gynaecium* (g) bent back. Same with *androecium* (a) curled and *gynaecium* (g) straight. The positions of *anaroecium* and *gynaecium* favour cross-pollination.


Fig. 266. Verbenaceae (সেগুণ, Teak ***Tectona grandis***.)

A—A portion of branch bearing *leaves* (l), *flowers* and *fruits* (f). B—Magnified view of a flower showing *corolla* (c), *androecium* (a) and *gynaecium* (g).

Fig. 267. Labiatae (তুলসী, Tulsi, ***Ocimum sanctum***).

A—A portion of the plant with *inflorescence* (f) and *leaves*. B—Floral diagram showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a, *absent stamen* (as) and *gynaecium* (g).



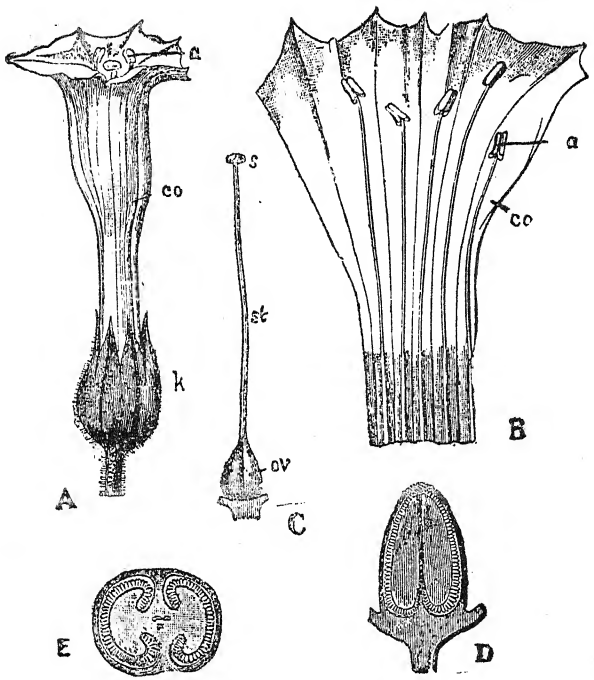



Fig. 268. Solanaceae (তামাক Tobacco, ***Nicotiana Tabacum***).

A flower showing *calyx* (k), *corolla* (co) and *androecium* (a). **B**—*Corolla* (co) of the flower cut open and showing epipetalous *stamens* (a). **C**—A flower with calyx, corolla and androecium removed showing *stigma* (s), *style*, (st) and *ovary* (ov). **D**—*Longitudinal* section of *fruit*. E—*Transverse* section of *fruit*.

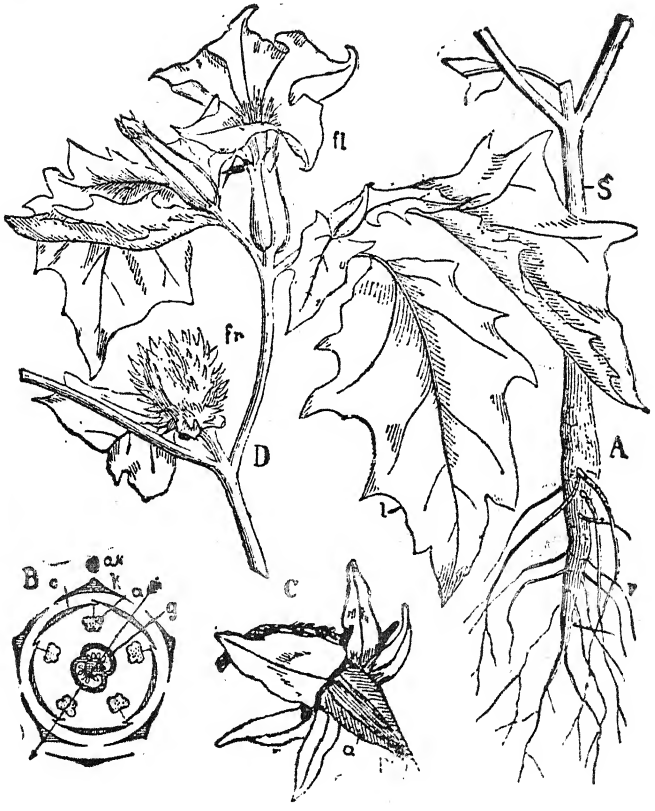



Fig. 269. Solanaceae (ধুতুরা, ***Datura Stramonium***).

**A**—A portion of *stem* (s) and *root* (r). **B**—Floral diagram showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a) and gynaecium (g). **C**—A flower of Potato (Solanaceae) showing anthers (a), *pores* (p), in the anthers and *stigma* (s). **D**—A portion of a branch showing *leaves*, *flowers* (fl) and fruit (fr).

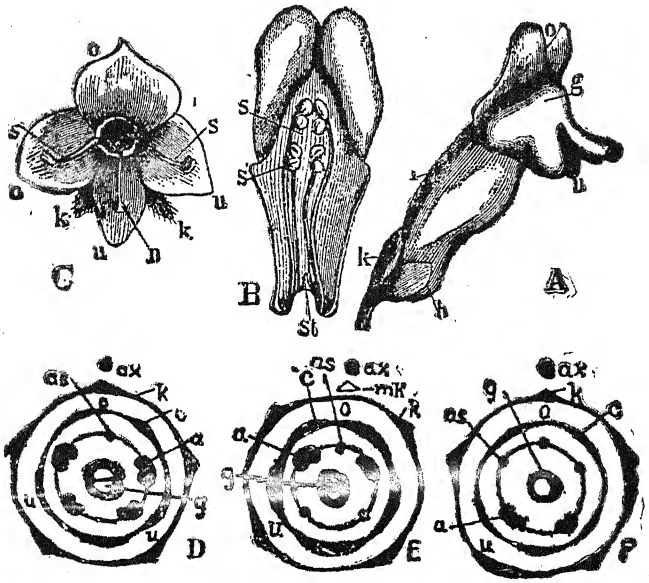



Fig. 270 **Scrophulariaceae.**

A—A flower showing *calyx* (k); tube of *corolla* (r) which is saccate at (h), *upper lip* (o), *under lip* (u) with a prominence (g). B—*Corolla* cut open and showing *four stamens* (2 long and 2 short) and a *rudimentary stamen* (st). D, E & F—Floral diagrams of which (D) is common; *calyx* (k), *corolla* (c), *androecium* (a), *absent stamen* (as), *gynaecium* (g), *mother-axis* (ax).

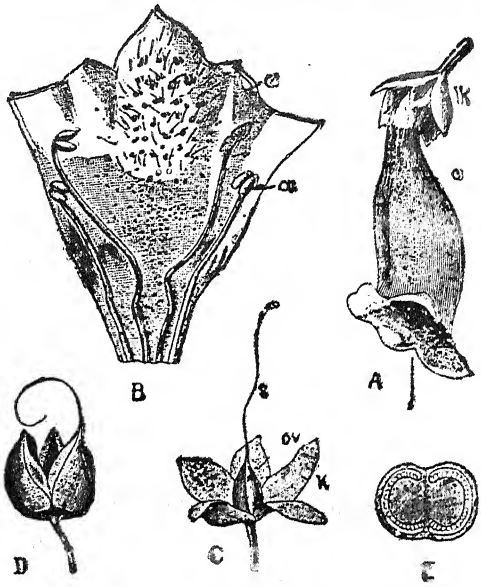



Fig. 271. Scrophulariaceae.

A—A flower showing *calyx* (k) and *corolla* (c). B—*Corolla* (c) cut open and showing the *four epipetalous stamens* (a). C—Flower showing *calyx* (k), *style* (s) and *ovary* (ov). D—A *fruit*. E—*Transverse* section of *fruit*.

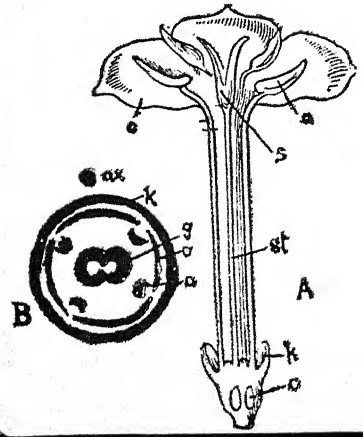



Fig. 272. Rubiaceae (চিরঞ্জন, Rangan, ***Ixora coccinea***).

A—*Longitudinal* section of a flower showing *calyx* (k), *corolla* (c), epipetalous *stamens* (a), *stigma* (s), *style* (st), *ovary* (o). B—Floral diagram showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g).

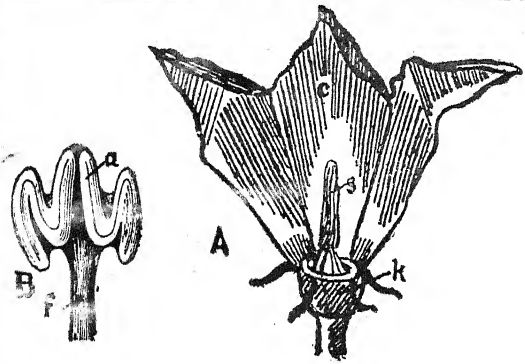



Fig. 273. Cucurbitaceae (লাউ, Low, ***Lagenaria vulgaris***).

A—Staminate flower with *calyx* (k), *corolla*, a portion of which has been removed and *androecium* (s). B—A portion of *stamen* showing *filament* (f) and *sinuous anther* (a).

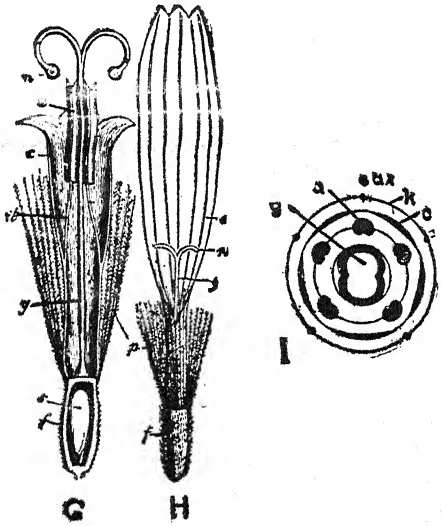



Fig. 274. Compositae.

C—*Longitudinal section* of a *disc floret* showing *calyx* represented by *pappus* (p), *tubular corolla* (c), *syngenesious anthers* (a), *free filaments* (st), *ovary* (f) containing *ovule* (s), *style* (g), and *bifid stigma* (n). H—A *female ray floret* showing *calyx* represented by *pappus* (p), *ligulate corolla* (c), *bifid* stigma (n), *style* (g) and *ovary* (f). I—Floral diagram of *disc floret* showing *mother-axis* (ax), *calyx* (k), *corolla* (c), *androecium* (a) and *gynaecium* (g).

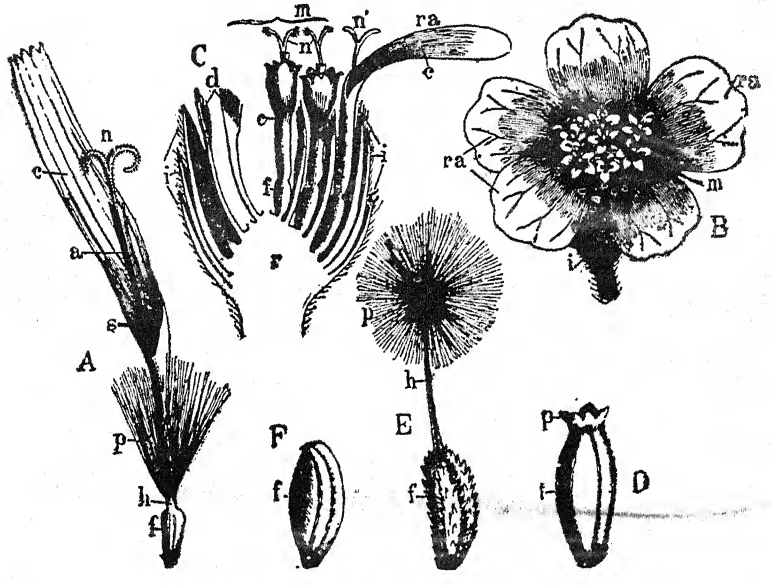



Fig. 275. Compositae.

**A**—A flower showing *calyx* represented by pappus (p), *ligulate corolla* (c), *stamens* consisting of *anthers* (a) and *filaments* (s), *ovary* (f), *bifid stigma* (n). **B**—An *inflorescence* (capitulum) showing *ray florets* (ra), *disc florets* (m) and *involucre* (i). **C**—Longitudinal section of a *capitulum* showing the *axis* of the inflorescence (r), *involucre* (i), *ray floret* (ra), with *ligulate corolla* (c), *disc florets* (m) with *tubular corolla* (c), *ovary* (f), *bifid stigma* (n) and *bracteoles* or *paleae* (d), **D, E & F**—Different kinds of *fruits* with a *scaly pappus* (P of D), *hairy pappus* (P of E) and *no pappus* (F).